NASA EP-14 REV. 5-64

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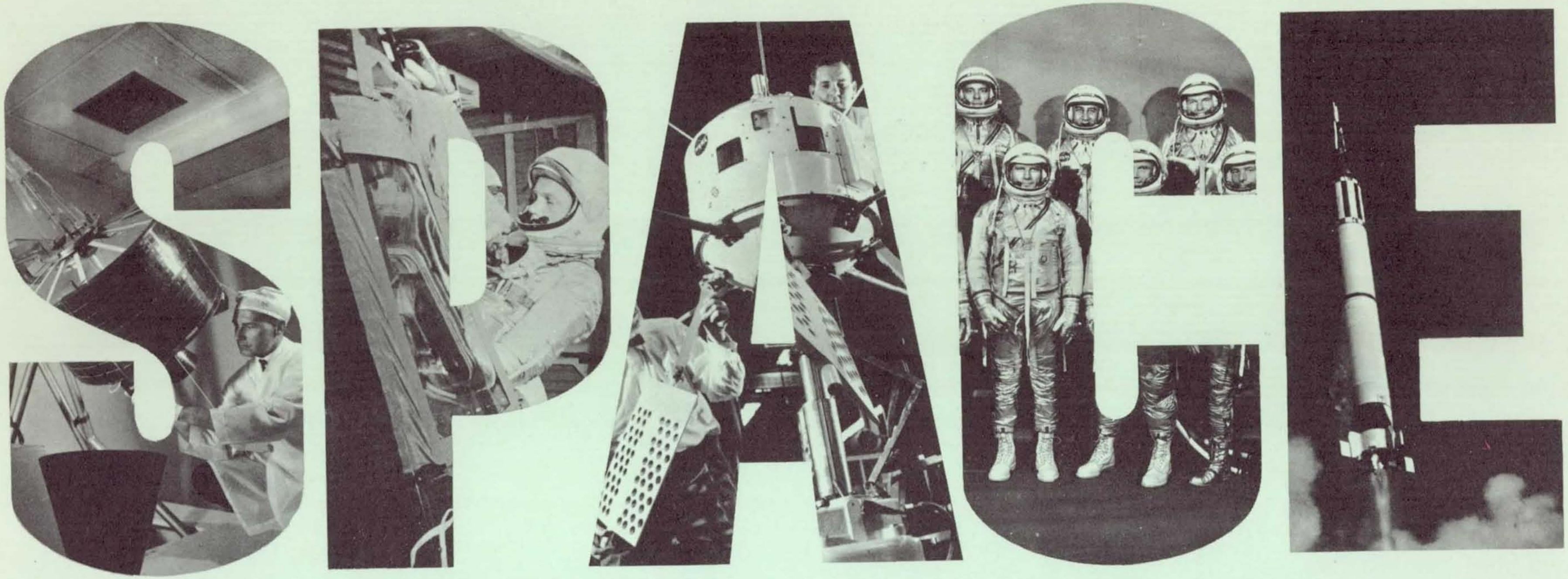

A PICTORIAL REVIEW

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

THE AGE OF SPACE

If there has been a single factor responsible for our success over the past two hundred years, it has been the characteristic American confidence in the future. It was such a confidence which brought the first colonists westward across the Atlantic to settle the Eastern shores. It was that same confidence which brought other generations westward across the continent to build up our country all the way to the Pacific.

Today there are those who argue that we should not push forward into new realms or new enterprises except when there is clear evidence of competition from other nations. I believe the American people reject the concept that their future shall be measured by the reaction to accomplishments of others.

America's commitment to the exploration of space for peaceful purposes is a firm commitment. We will not retreat from our national purpose. We will not be turned aside in our national effort by those who would attempt to divert us.

Our national purpose in space is peace—not just prestige.

President Lyndon B. Johnson

This country's greatest achievement in space, in my opinion, has been the creation of a truly major national effort—as dynamic as it is urgent—for mobilizing large resources of scientific knowledge and advanced technology to achieve clearly defined national goals.

The significant fact of this decade, I submit, will be more than the landing of a team of United States explorers on the moon; it will be the demonstration of the will and ability of our Nation, in full observance of the democratic processes of a free people, to organize and carry out the great effort that makes such a landing possible.

JAMES E. WEBB
Administrator, NASA
Los Angeles, California

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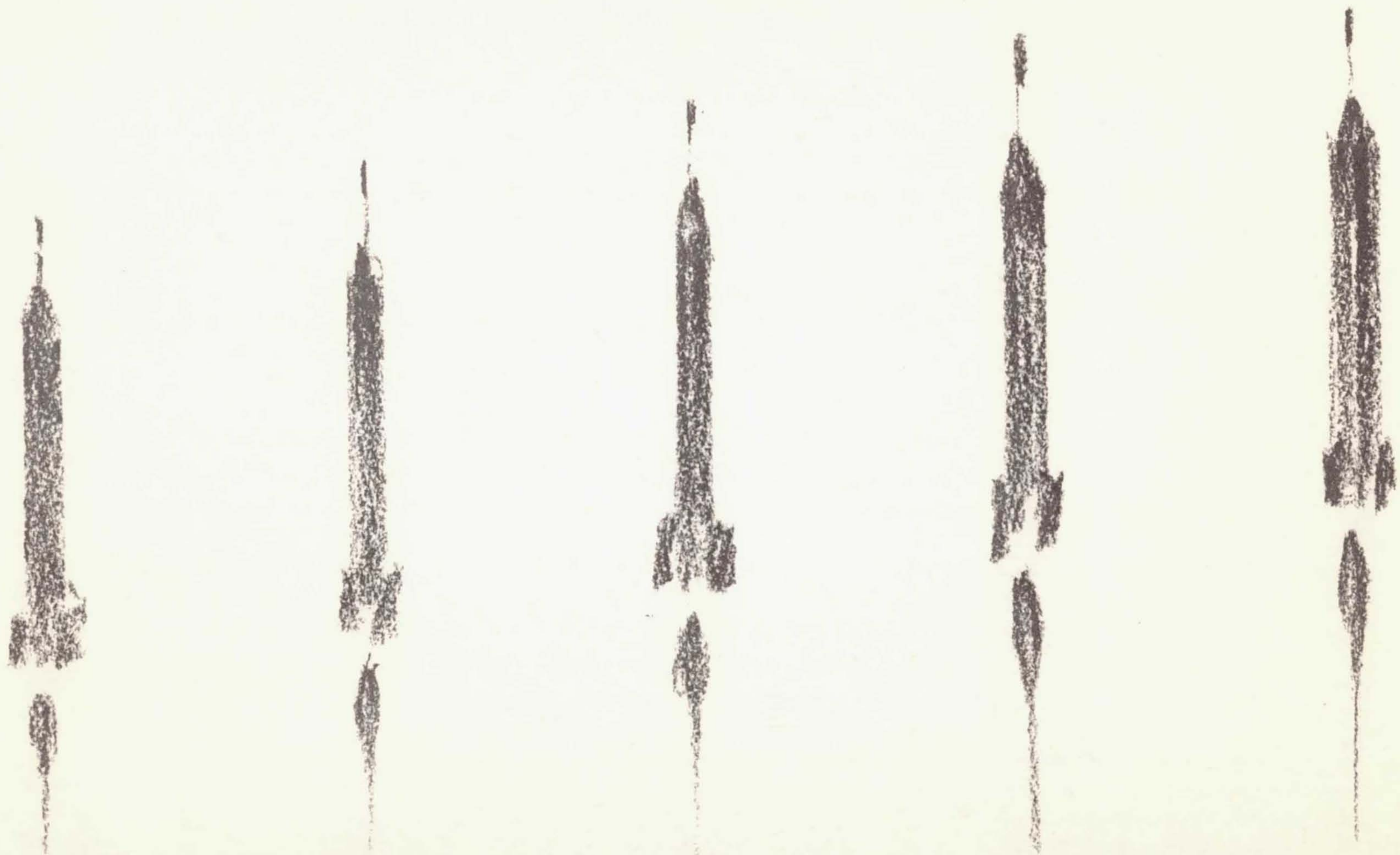
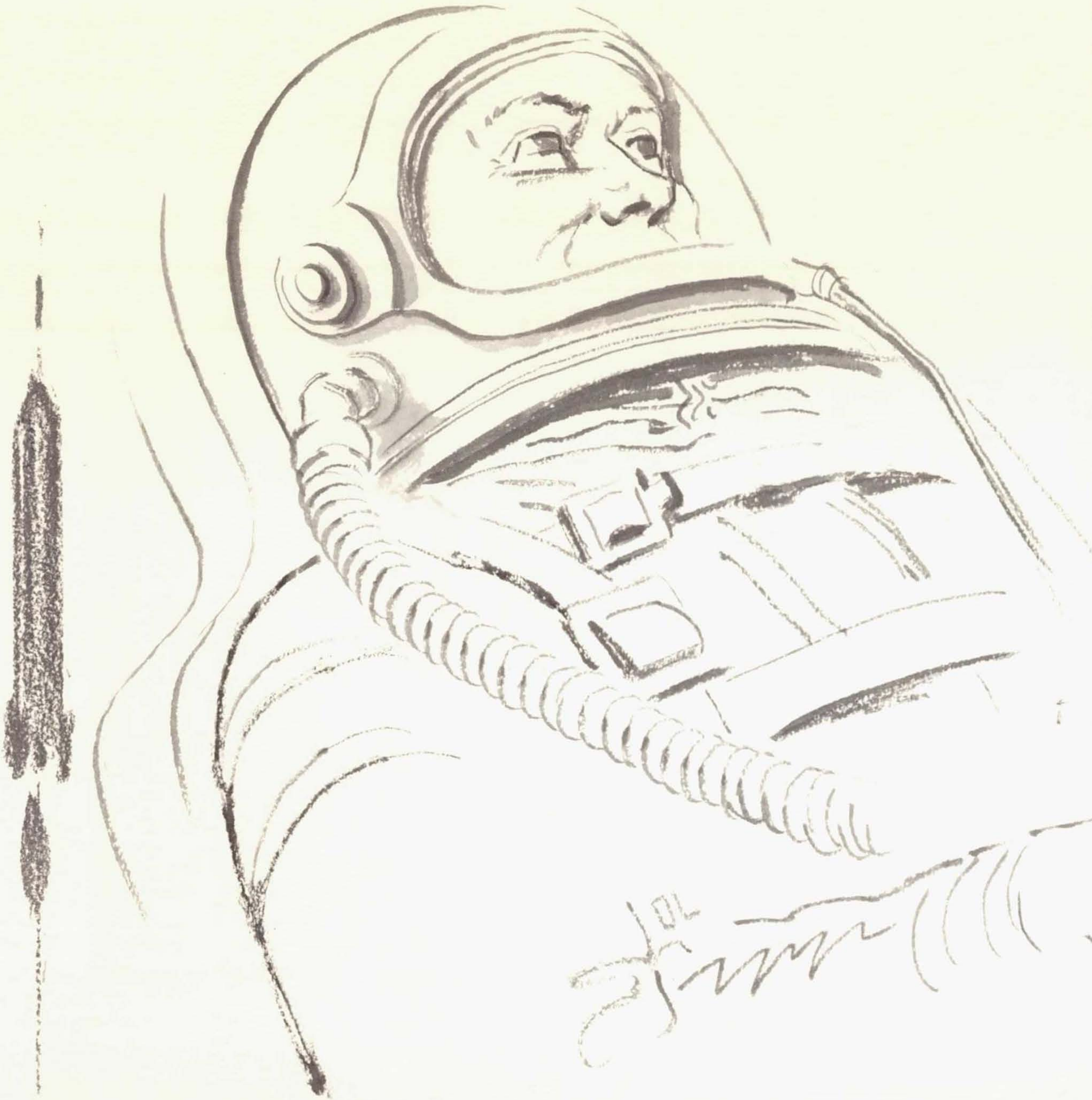




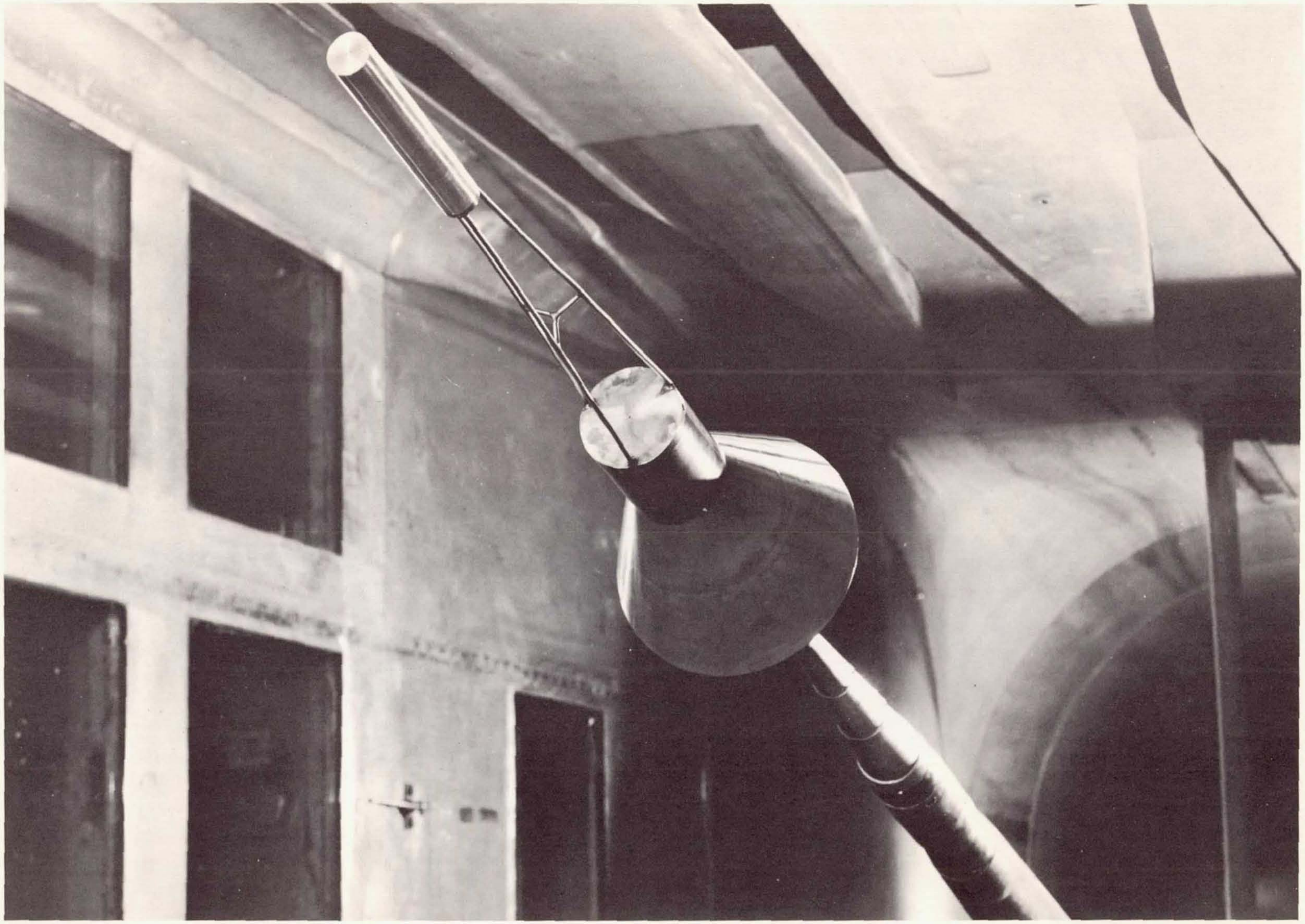
AMERICA'S MANNED SPACE FLIGHT PROGRAM TAKES GREAT STEP FORWARD

On May 16, 1963, Astronaut L. Gordon Cooper, Jr., concluded an epic 22-orbit Mercury flight in his Faith 7 spacecraft. Following this journey, America's manned space flight program moved beyond the pioneering Project Mercury to Project Gemini.

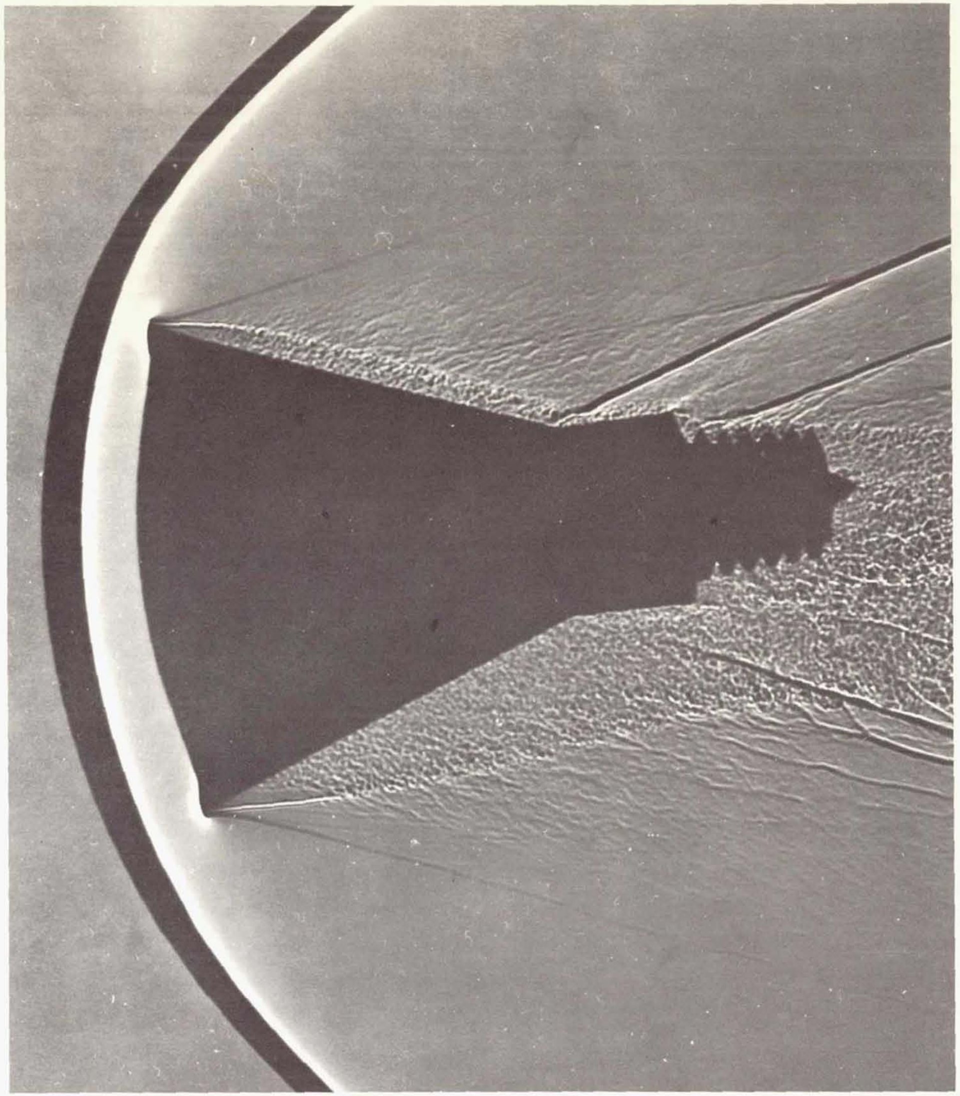
In Gemini, NASA will explore the problems of manned space flight in greater depth than was possible with Mercury. Among the techniques to be developed in Gemini is orbital rendezvous—the joining of craft in orbit. Gemini will lead to Project Apollo whose goal is the landing of American explorers on the moon in this decade.

Project Mercury has laid a sound foundation for greater achievements by its successor projects. It has demonstrated that man can live and work in space, can augment the reliability of automatic equipment, and can clarify and add to data provided by instruments.

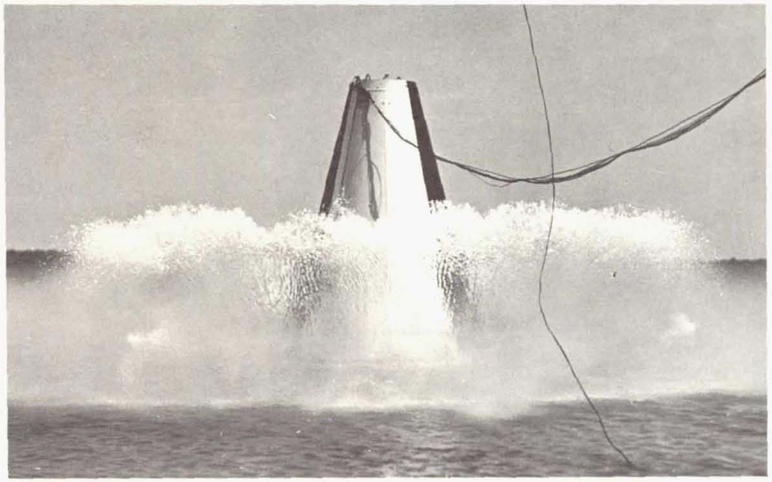
The progress of the first five years of America's manned space flight program is reflected principally in Project Mercury which was initiated October 5, 1958, just four days after NASA began operations. As a result, this section chiefly depicts Project Mercury. It also gives a glimpse of developments in Projects Gemini and Apollo.



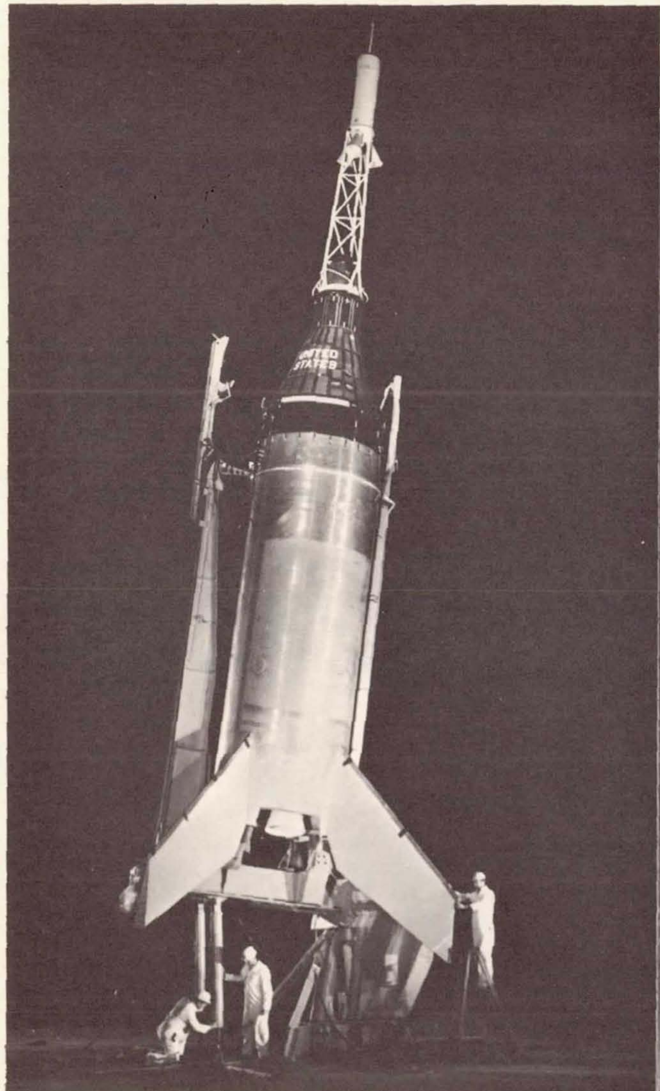
The design of the Mercury spacecraft is the product of exhaustive laboratory studies such as the wind tunnel test portrayed at left . . .



. . . the test at the right in which a model is fired like a bullet into an on-rushing stream of air (resulting airflow is clearly visible) . . .



. . . and water drop tests.

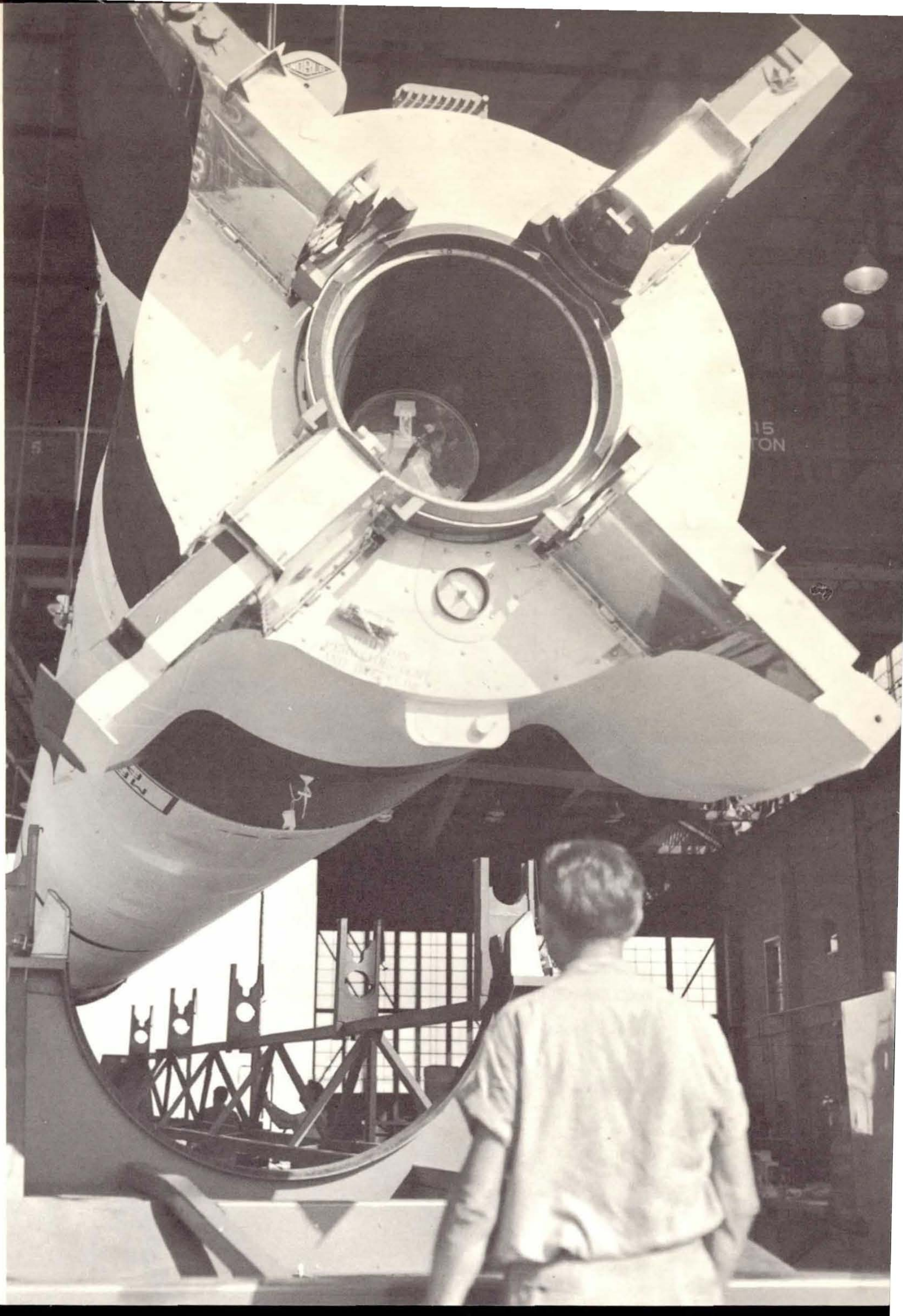


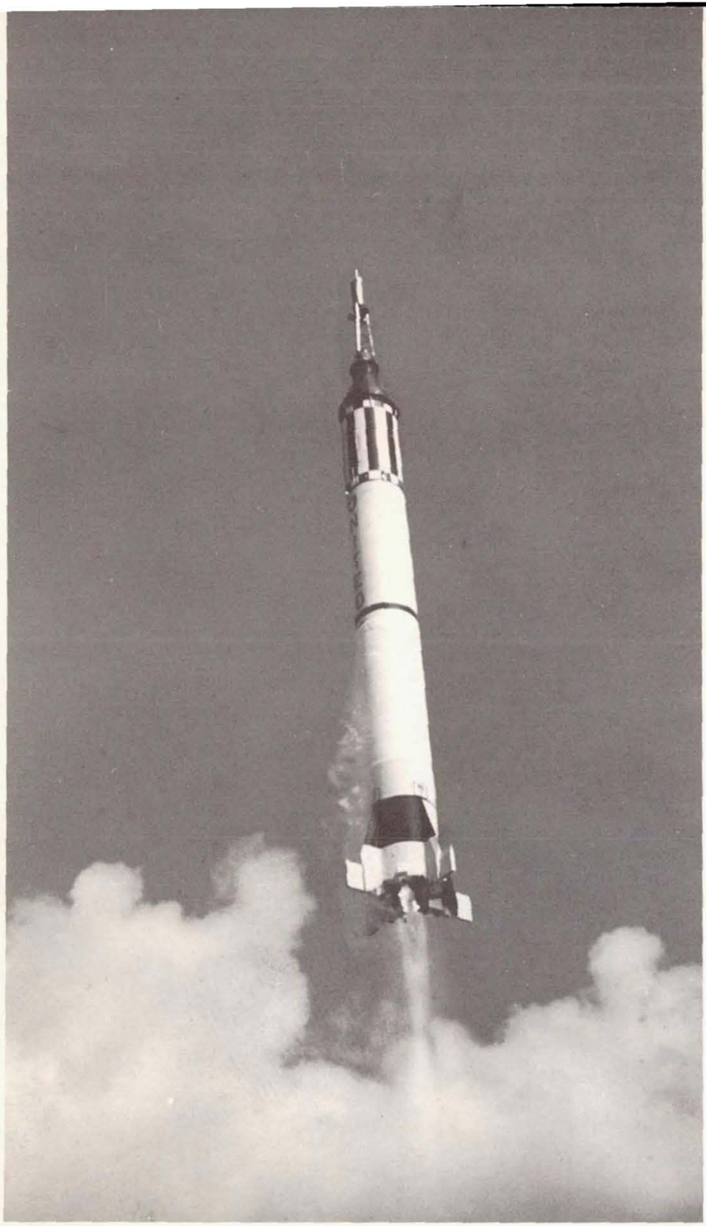
UNITED
STATES

After laboratory studies came tests of boilerplate models (models without instrumentation) to evaluate structural soundness in ballistic flight and the operation of the escape and landing system. Little Joe boosters, made up of a cluster of four Sergeant and four Recruit rockets, were employed for these tests (*far left*).

On December 4, 1959, Miss Sam (*left*), a rhesus monkey, was recovered alive and well after the Mercury escape rocket was deliberately triggered during a Little Joe flight.

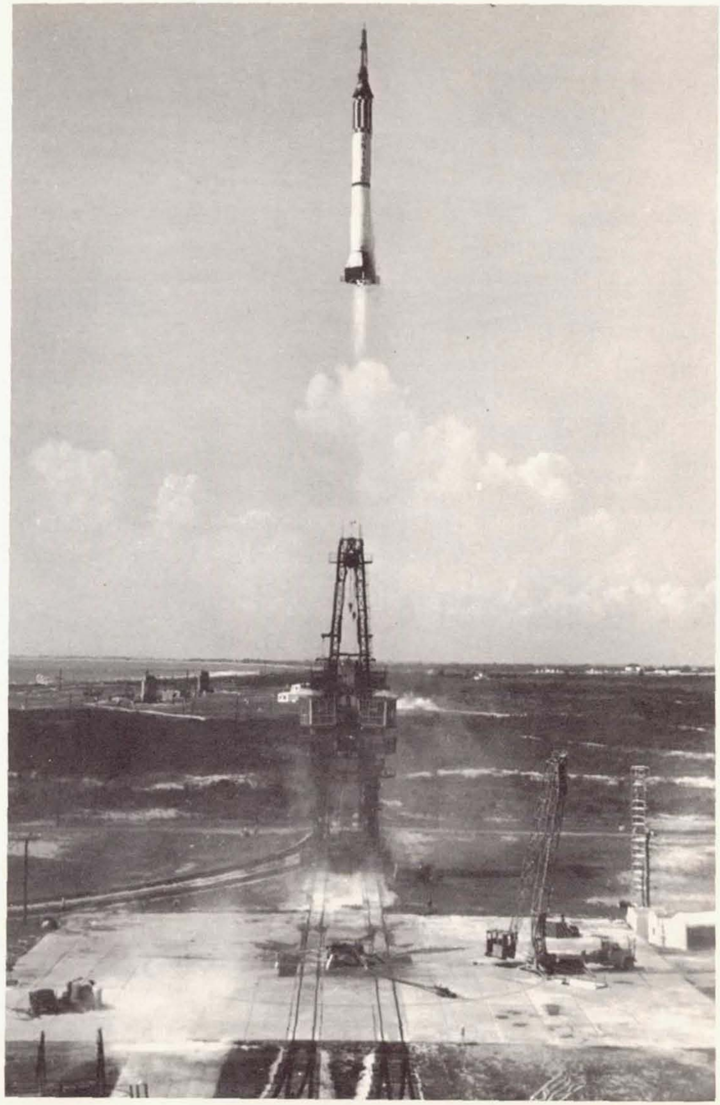
Modified Redstone rockets like this one were Mercury boosters in the next series of experiments.





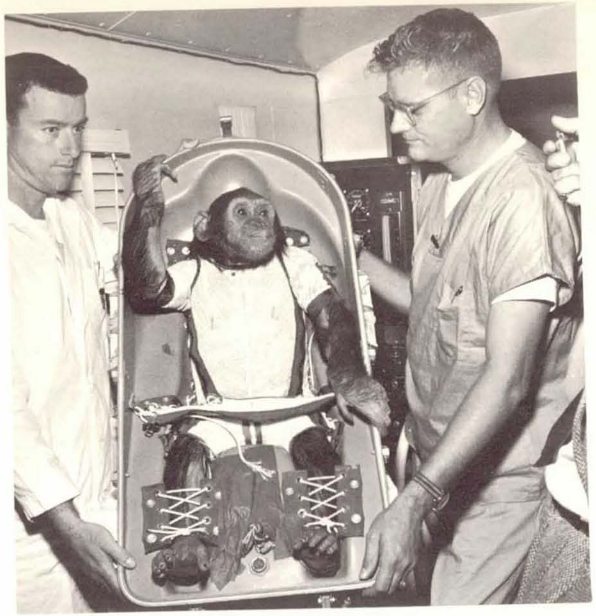
Redstone rockets Mercury beyond clouds. Maximum MR altitude was 115 miles; range, about 300 miles from Cape Canaveral launch site; landing point, in the Atlantic Ocean.

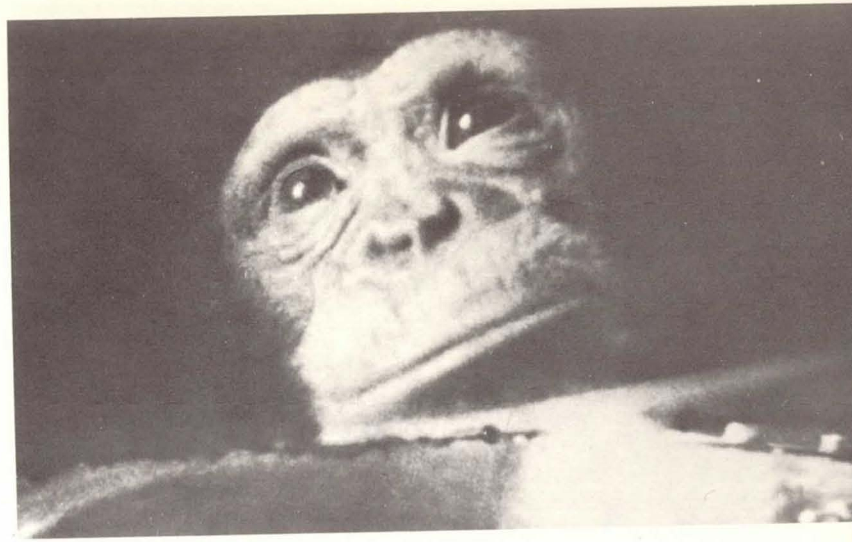
Redstone launching Mercury spacecraft. Mercury-Redstone (called MR) flights lasted about 15 minutes and reached a velocity of 5,000 miles per hour.



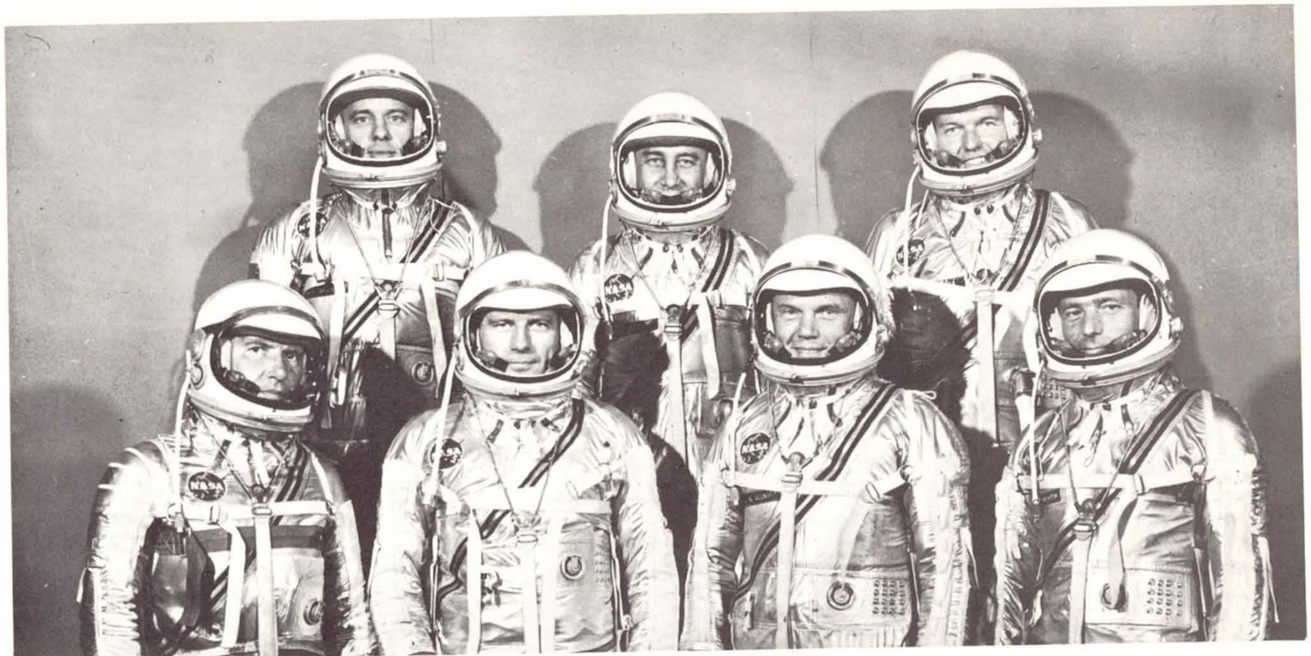
Ham relaxes with trainers (*right*), prior to his MR flight of January 31, 1961.

Ham photographed by an automatic camera during his flight (*far right*). The success of this flight set the stage for the first American astronaut to go into space.





A careful selection process resulted in the choice of seven Mercury astronauts on April 2, 1959. Left to right: Front—Walter M. Schirra, Jr.; Donald K. Slayton; John H. Glenn, Jr.; and M. Scott Carpenter. Back—Alan B. Shepard, Jr.; Virgil I. Grissom; and L. Gordon Cooper, Jr.



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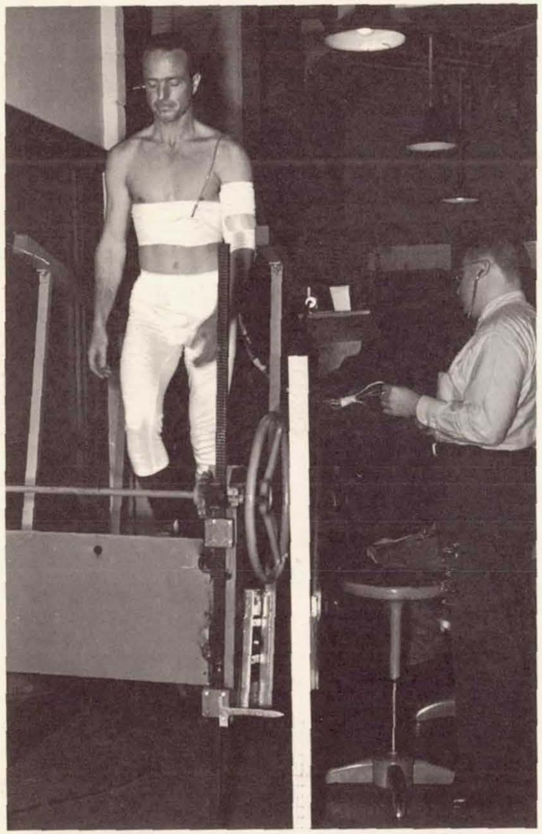
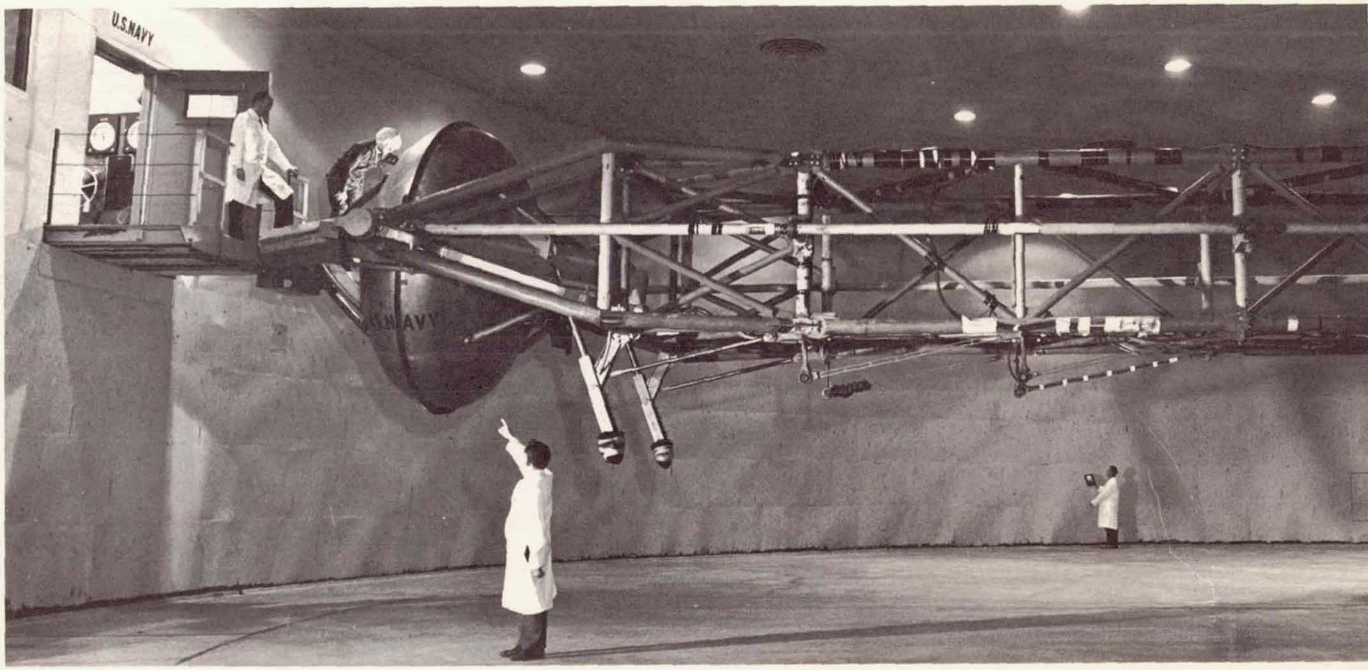
An intensive training program prepared the astronauts for space travel. Astronaut Carpenter takes stress test on treadmill.

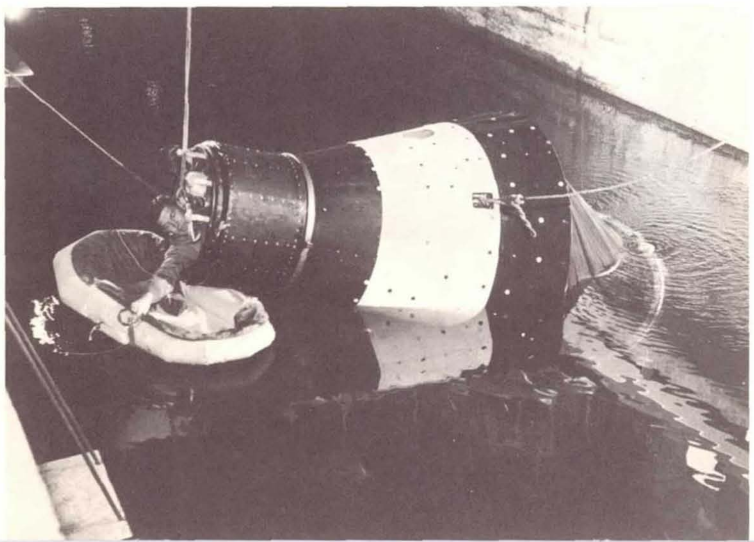


Astronaut enters gondola of giant centrifuge that will duplicate high gravity forces expected during take-off and entry into atmosphere.



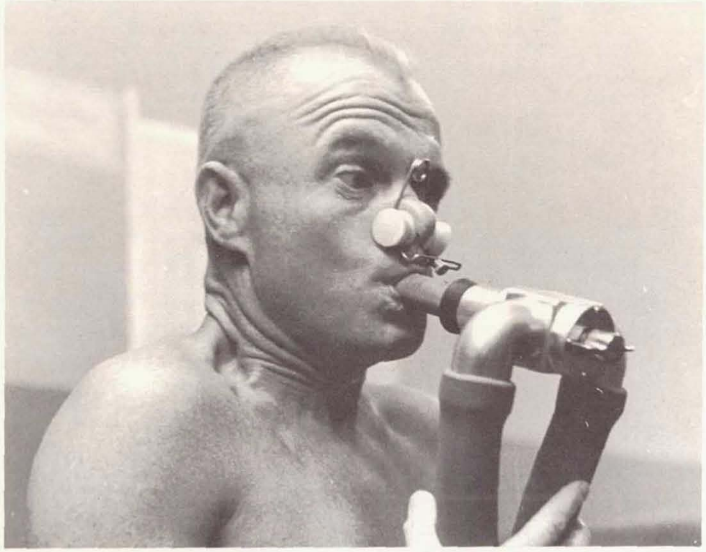
Astronauts experience brief period of weightlessness in aircraft flying a parabolic arc. At one part of such an arc, centrifugal force equals gravitational force.

Astronaut Schirra practices leaving spacecraft from top after water landing.



Astronaut Slayton in isolation test.

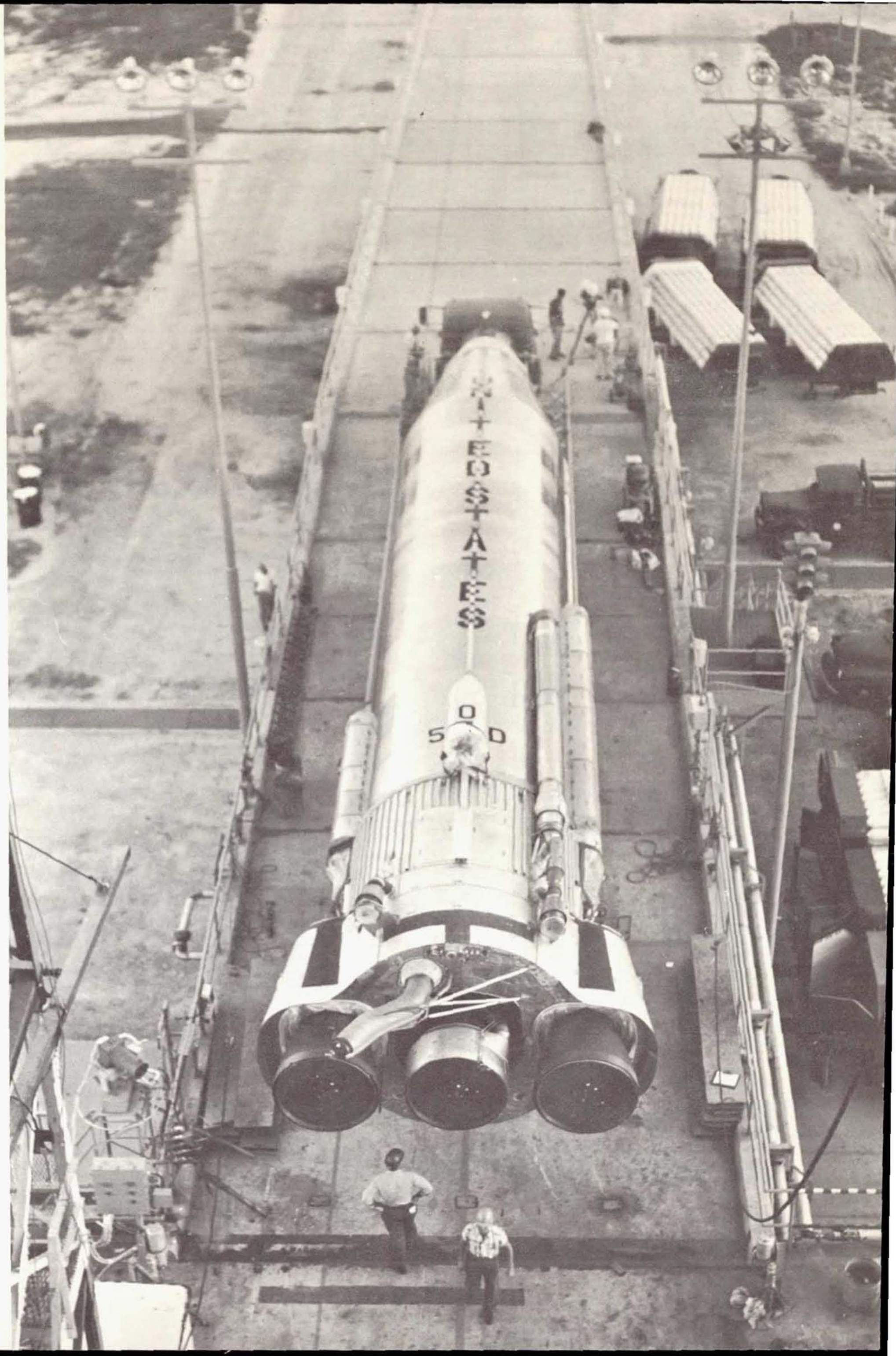
Astronaut Glenn takes respiratory test.



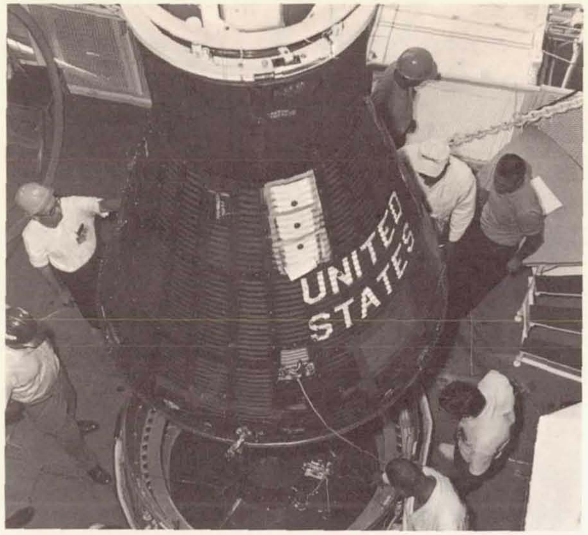
Couches molded to shapes of their bodies help astronauts to undergo the high-gravity forces associated with launch and entry into earth's atmosphere.

Astronauts made two Mercury-Redstone (MR) flights. Astronaut Shepard is recovered by helicopter after his flight of May 5, 1961.

The successful MR experiments paved the way for Mercury orbital flights employing the mighty Atlas booster. Here, the Atlas is moved into position for erection in its launch tower.



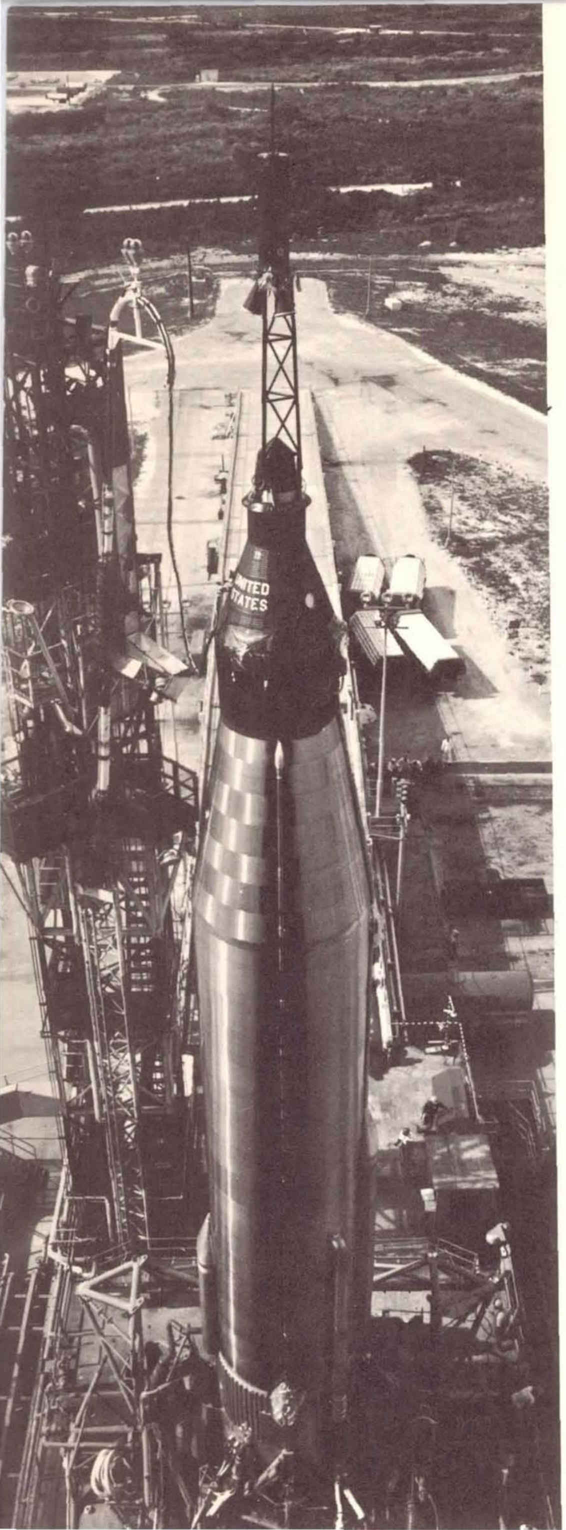
Astronaut Grissom prepares to enter his spacecraft for MR flight of July 21, 1961. Shepard and Grissom were subjected to forces as high as 11 g—11 times their weight.

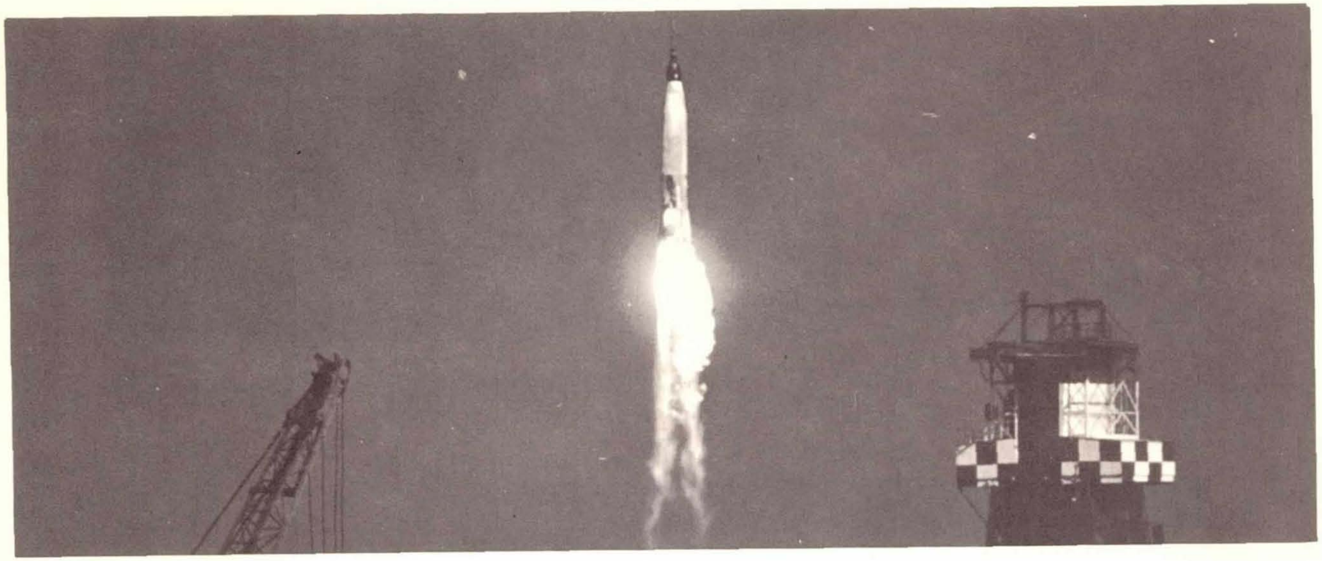


The Mercury spacecraft is positioned for mating with Atlas.

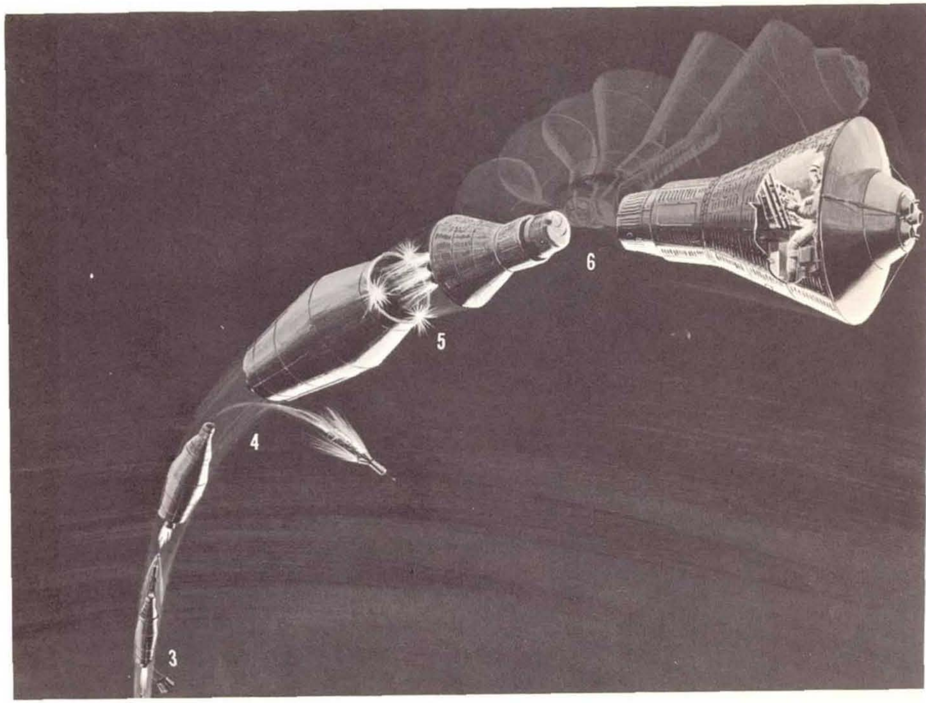
Striking picture of Hurricane Debbie provides a sharp view of the hurricane eye. It was taken by an automatic camera in an unmanned Mercury orbital flight on September 13, 1961. The flight qualified the spacecraft and the Mercury ground tracking and communications network for manned orbital missions.

Enos romps with trainer before his two-orbit Mercury trip of November 29, 1961. His flight couch is in foreground.



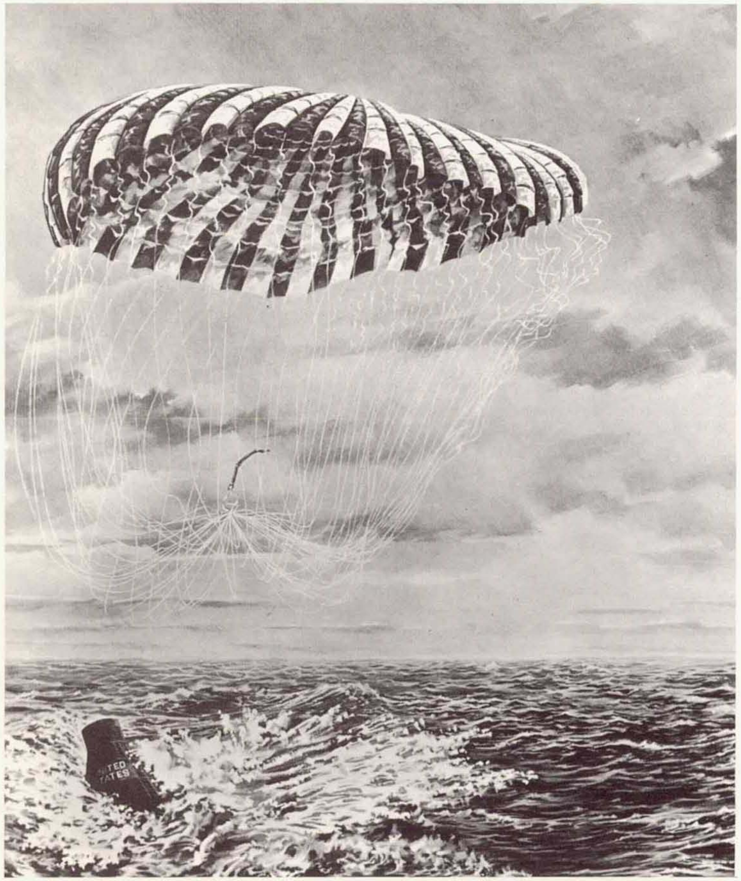


The major phases in a Mercury flight: (1) Service tower moves away from Atlas-Mercury assembly (*left*); (2) Atlas roars toward outer space (*above*).

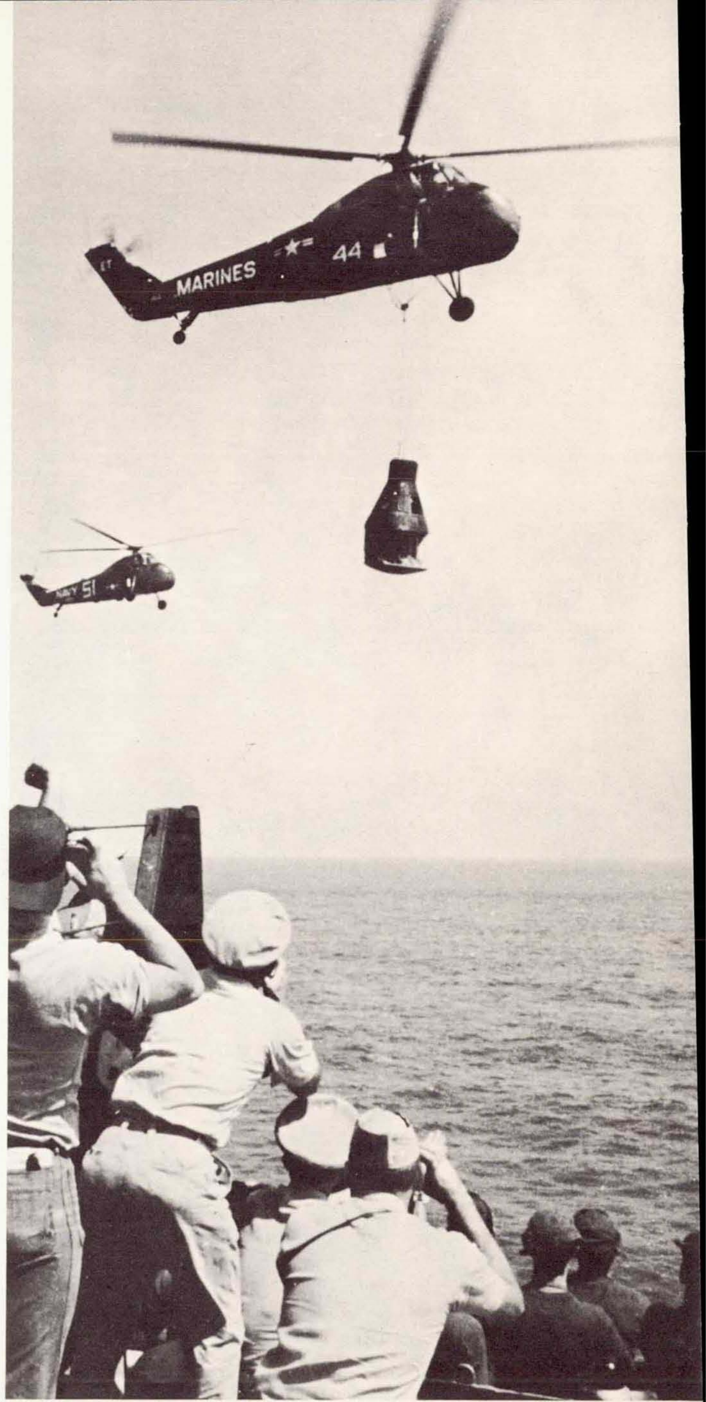


(3) Booster rockets burn out and fall away; (4) Escape rocket tower separates; (5) Atlas separates from spacecraft in orbit; (6) Mercury capsule turns blunt end forward for orbital flight.

(7) After fiery entry into atmosphere, capsule is lowered to ocean landing by parachute.



(8) Splashdown at end of a Mercury space flight.



(9) Recovery of the spacecraft by helicopter lift to waiting ship.

Four astronauts completed Mercury orbital flights. The first was Astronaut Glenn, shown entering Friendship 7 spacecraft before three-orbit journey of February 20, 1962.

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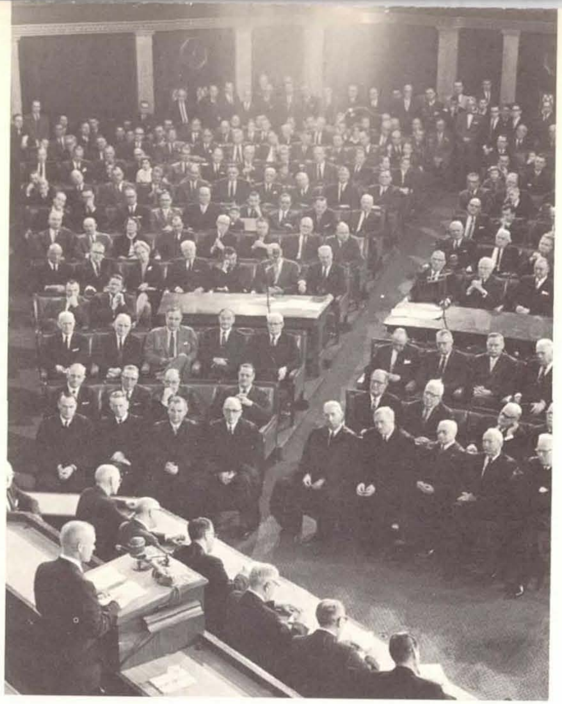
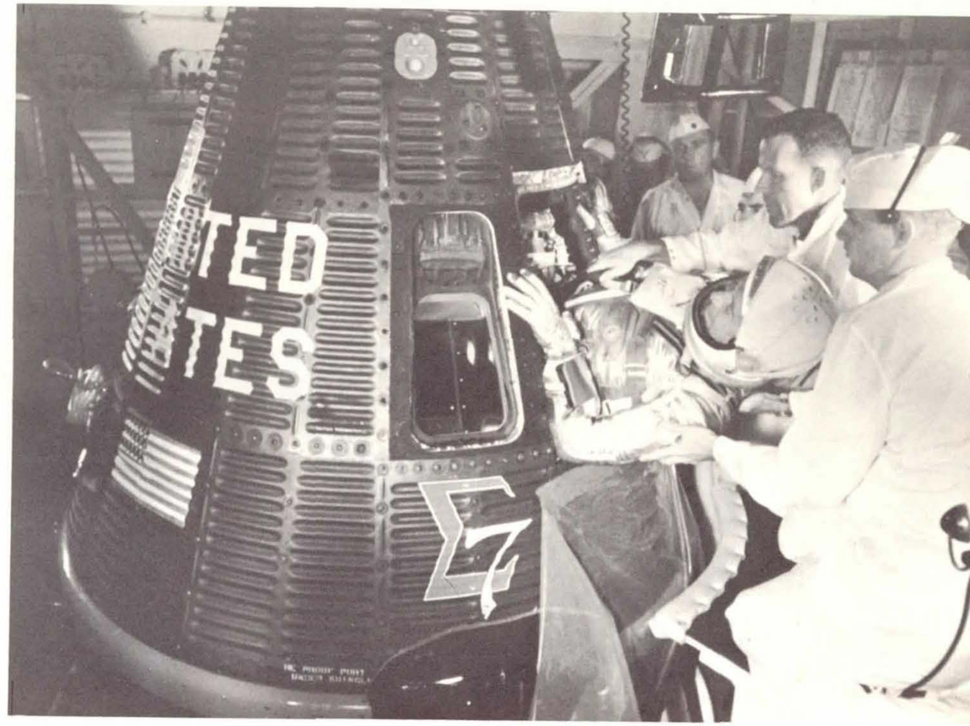
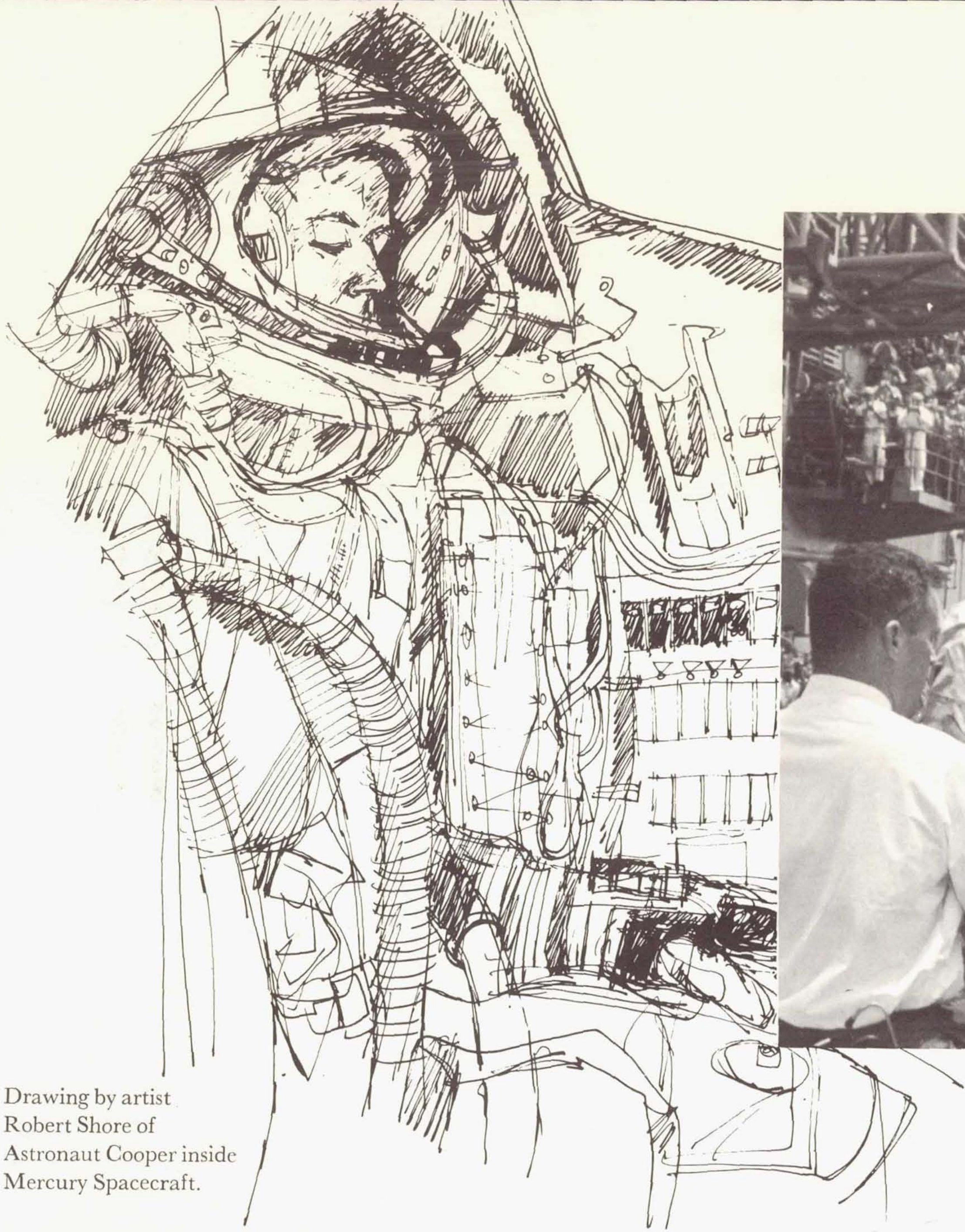


Glenn addresses joint
session of Congress
after historic flight.



Astronaut Walter Schirra is assisted into his Sigma 7 spacecraft prior to his six-orbit voyage of October 3, 1962.

Astronaut Carpenter, suited up and ready for three-orbit trip of May 24, 1962. He carries portable air conditioner.



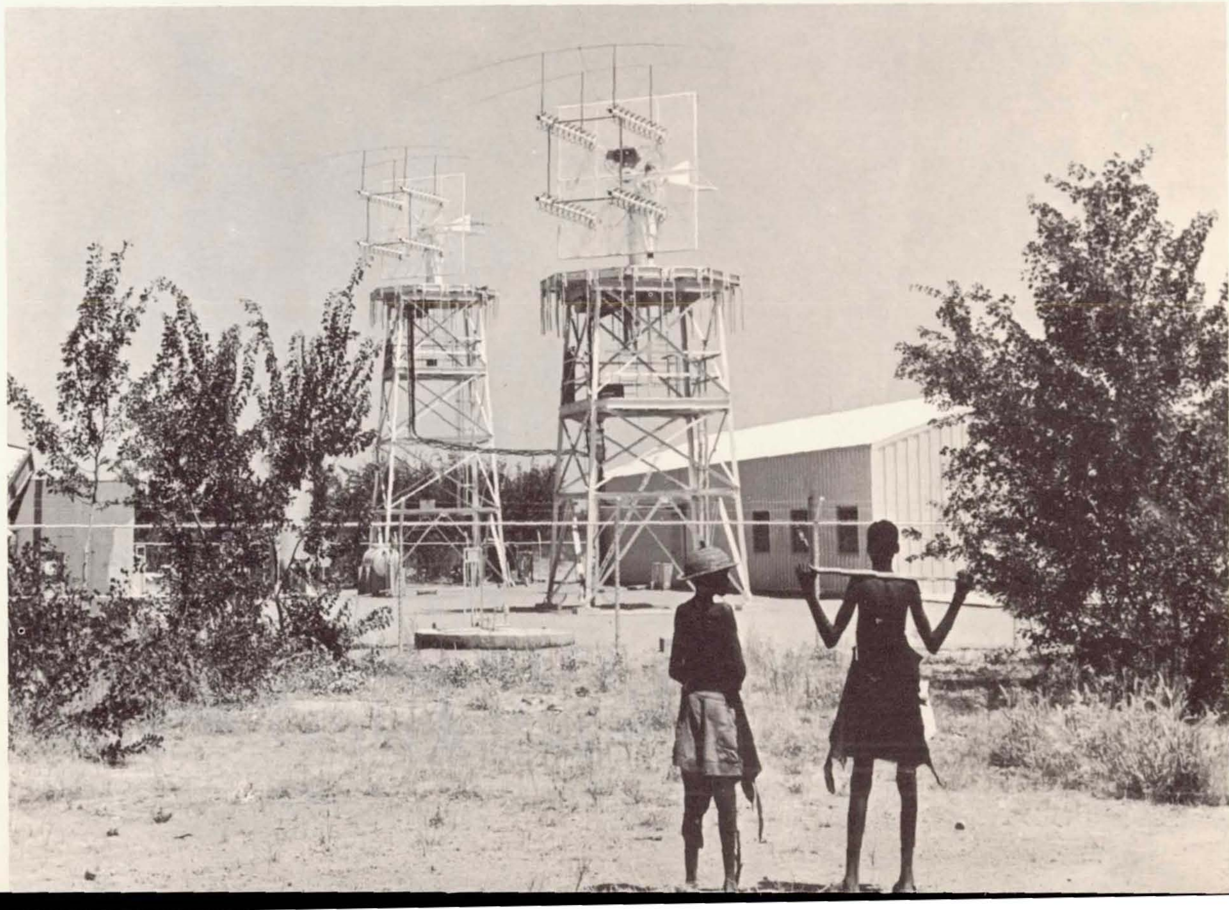
Drawing by artist
Robert Shore of
Astronaut Cooper inside
Mercury Spacecraft.

Astronaut Cooper is assisted from his Faith 7 Mercury spacecraft onto deck of U.S. Navy aircraft carrier Kearsarge after 22-orbit flight ending May 16, 1963.

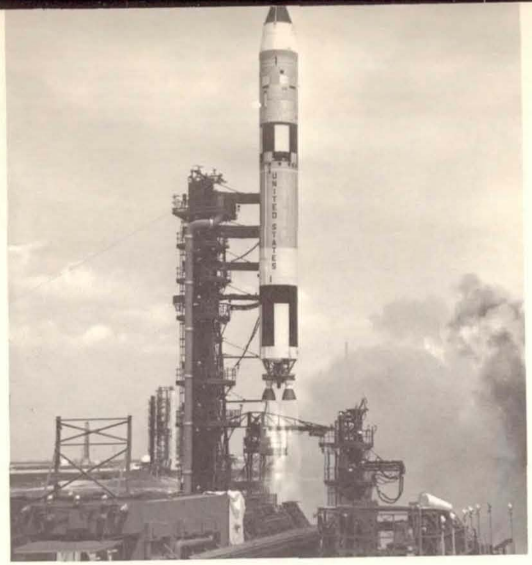
Robert Shore

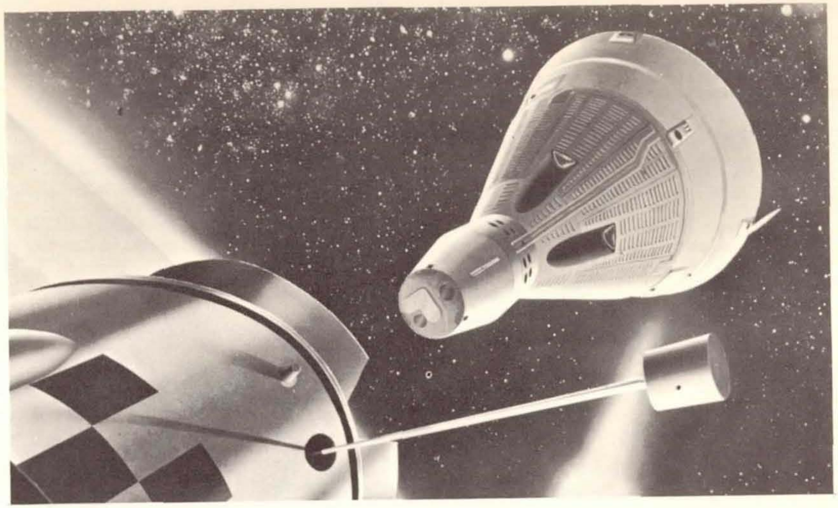
Astronaut Cooper waves to crowd after leaving Capitol where he addressed a joint session of Congress on May 21, 1963. With him are Vice President Lyndon B. Johnson and Senator Clinton B. Anderson of New Mexico.

Vital to the success of the Mercury program was the Mercury tracking and communications network of 16 radar and radio stations around the world. Nigerians watch operation of Mercury antenna at Kano.

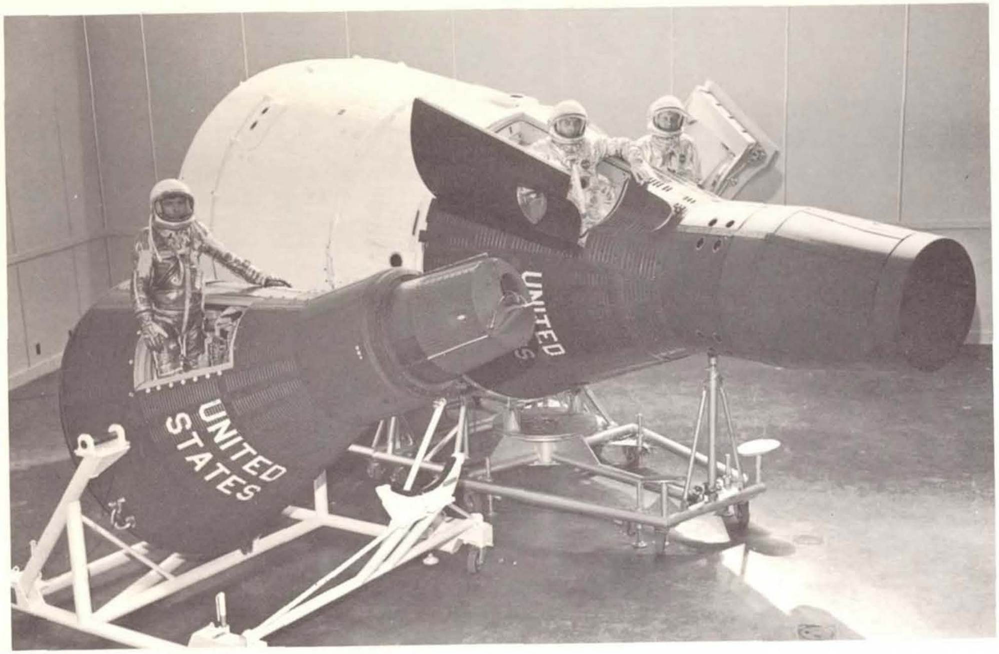


The Titan II launch vehicle lifting an unmanned Gemini spacecraft from a launch pad at Cape Kennedy on April 8, 1964. This first launch in the Gemini program resulted in an orbital flight for a test preparatory to later flights with astronauts aboard.

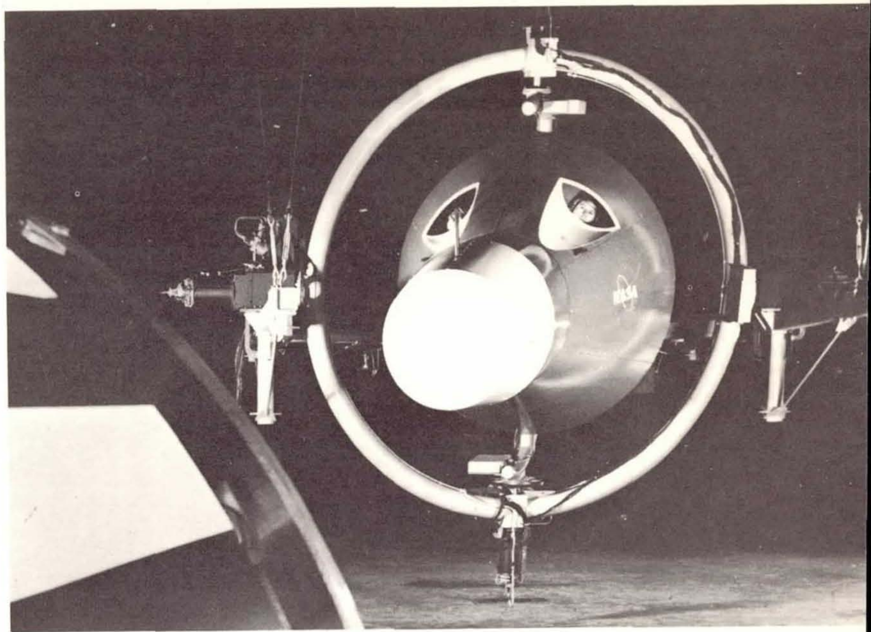




Artist's conception of Gemini rendezvous in space with Agena D launch vehicle. Success in this maneuver is a principal goal of Project Gemini.

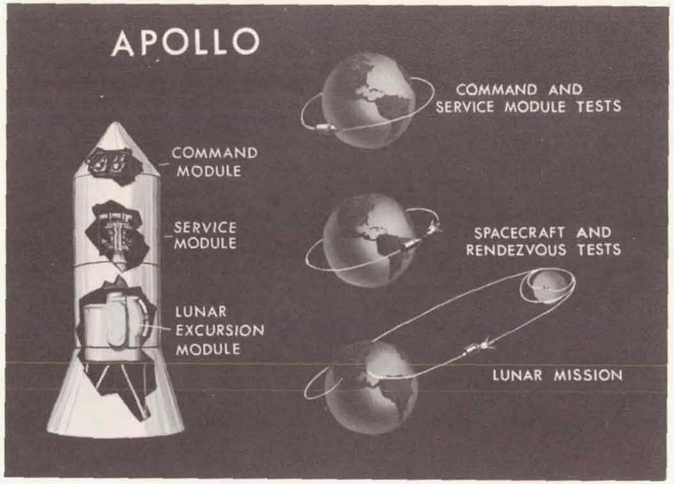


Mercury one-man spacecraft alongside mock-up of Gemini two-man spacecraft.

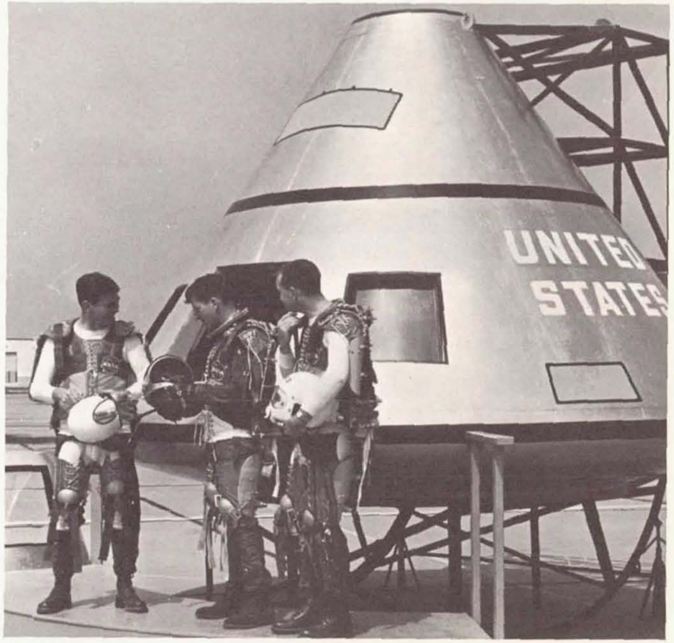


Full-scale simulators such as this one for orbital rendezvous have been built to prepare men and equipment for space flight.

Sketches indicate Apollo spacecraft as it will appear at launch from earth and depict the three Apollo steps toward landing American explorers on the moon. (The Apollo service module contains fuel and rockets to maneuver Apollo in space. The lunar excursion module will land two men on the moon and later rocket them back to the command module which will remain with the service module in lunar orbit.)

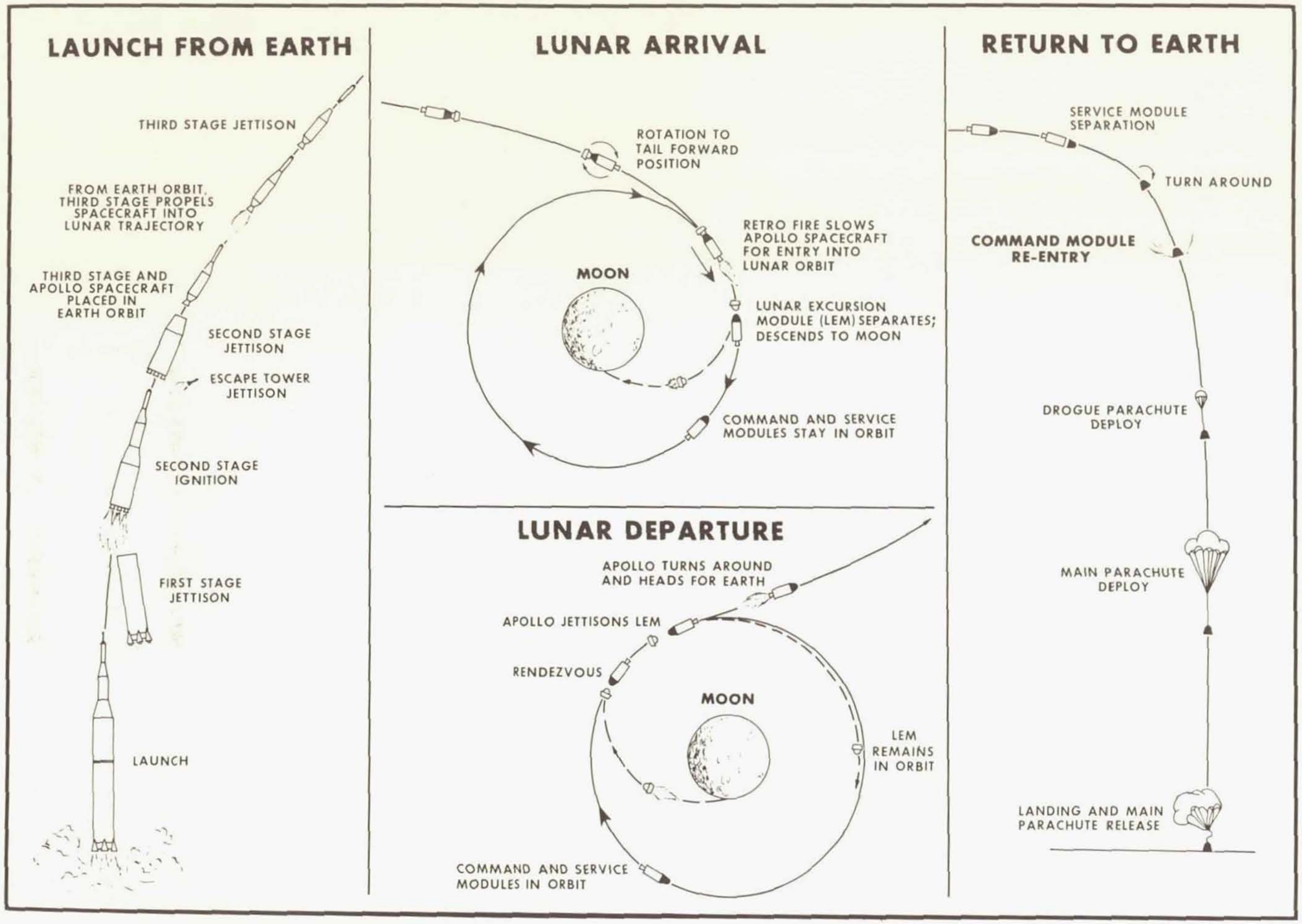


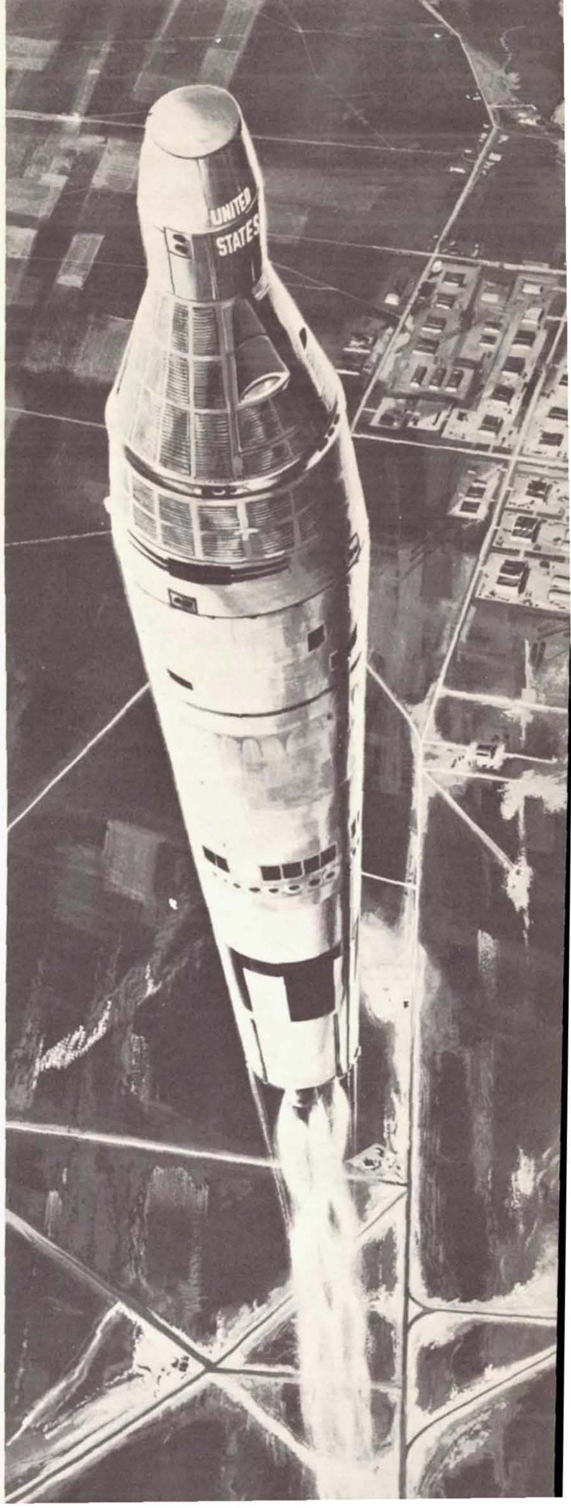
Interior of Apollo command module mock-up.



Preliminary mock-up of command module of Apollo spacecraft. The command module may be likened to the crew compartment of an airliner. The module will carry three men.

Sequence of major events in Apollo lunar exploration mission.

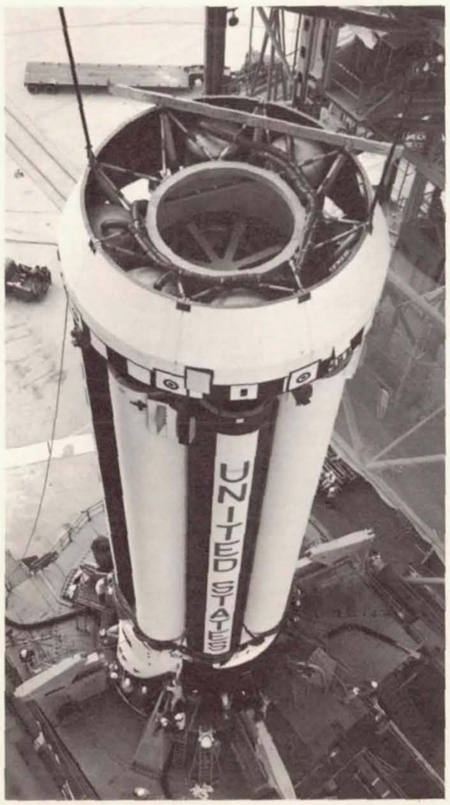


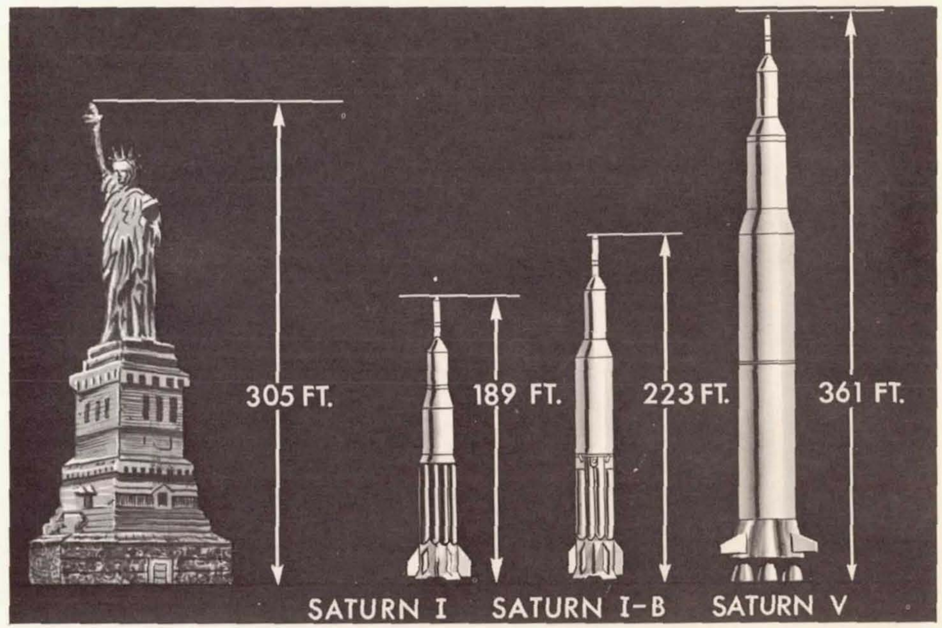


NASA has selected Titan II, an Air Force booster, to launch Gemini. Artist's sketch shows Titan II rocketing Gemini into orbit.

Saturn I first stage with inert upper stage is launched October 27, 1961, in first of ten programmed flight tests. First test with a powered second stage was conducted on January 29, 1964. It placed the world's heaviest satellite, weighing about 19 tons, into earth orbit.

NASA is forging ahead with development of the great boosters needed for Apollo and other advanced missions. Saturn I first stage, consisting of cluster of eight engines providing 1.5 million pounds of thrust, is erected on pad for flight test.

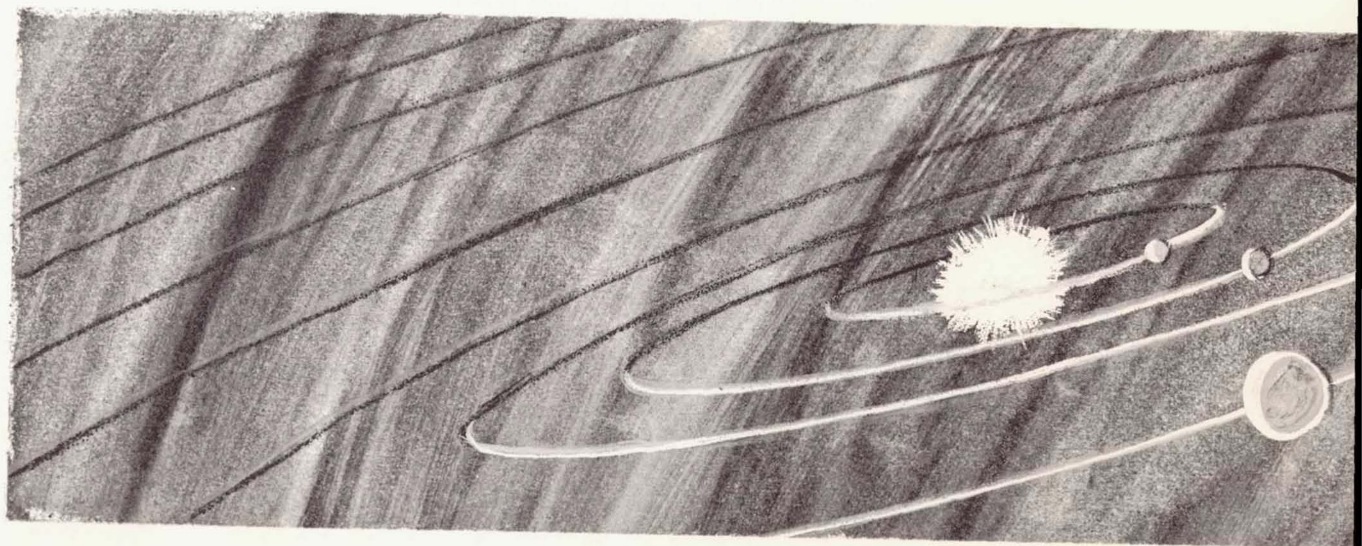




Apollo launch vehicles under development. Saturn I-B will have the same first stage as Saturn I but a more powerful upper stage. The first stage of Saturn V consists of a cluster of five 1.5 million pound thrust rockets generating 7.5 million pounds of thrust. Saturn V will launch Apollo to the moon.

Nine additional astronaut-trainees were selected September, 1962 to join the seven Mercury astronauts. They are, left to right; front: Charles Conrad, Jr.; Frank Borman; Neil Armstrong; John W. Young. Back: Elliott M. See, Jr.; James A. McDivvitt; James A. Lovell, Jr.; Edward H. White, II; and Thomas P. Stafford.

In October of 1963, NASA chose a third group of 14 astronaut-trainees, increasing the number of space pilots and trainees to 30. The new group, left to right, standing: Michael Collins, R. Walter Cunningham, Donn F. Eisele, Theodore C. Freeman, Richard F. Gordon, Jr., Russell L. Schweickart, David R. Scott, Clifton C. Williams, Jr. Seated: Edwin E. Aldrin, Jr., William A. Anders, Charles A. Bassett II, Alan L. Bean, Eugene A. Cernan, and Roger B. Chaffee.

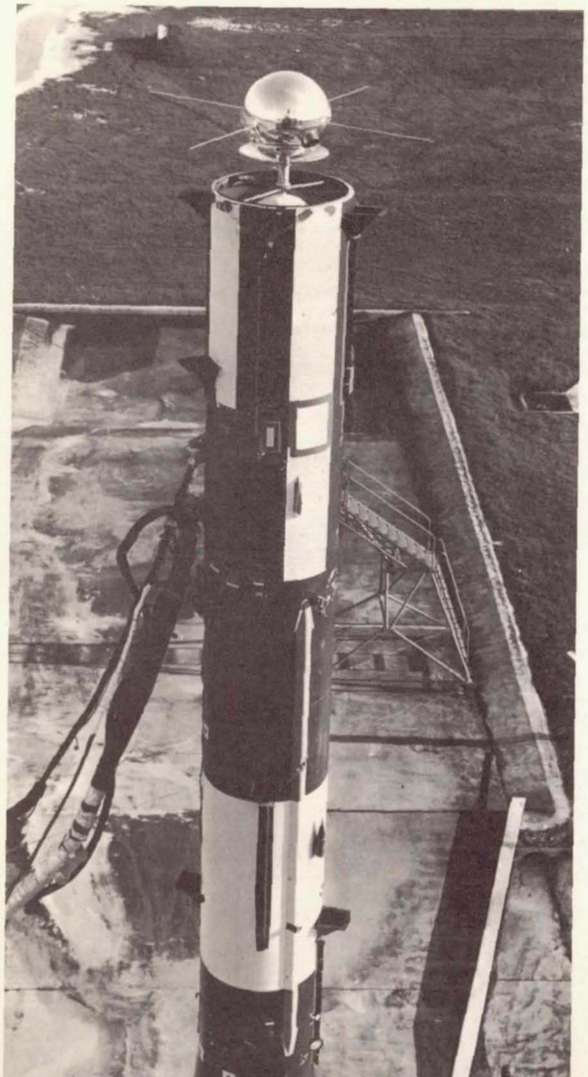


SPACE SCIENCES PROGRAM UNLOCKS MYSTERIES OF THE UNIVERSE

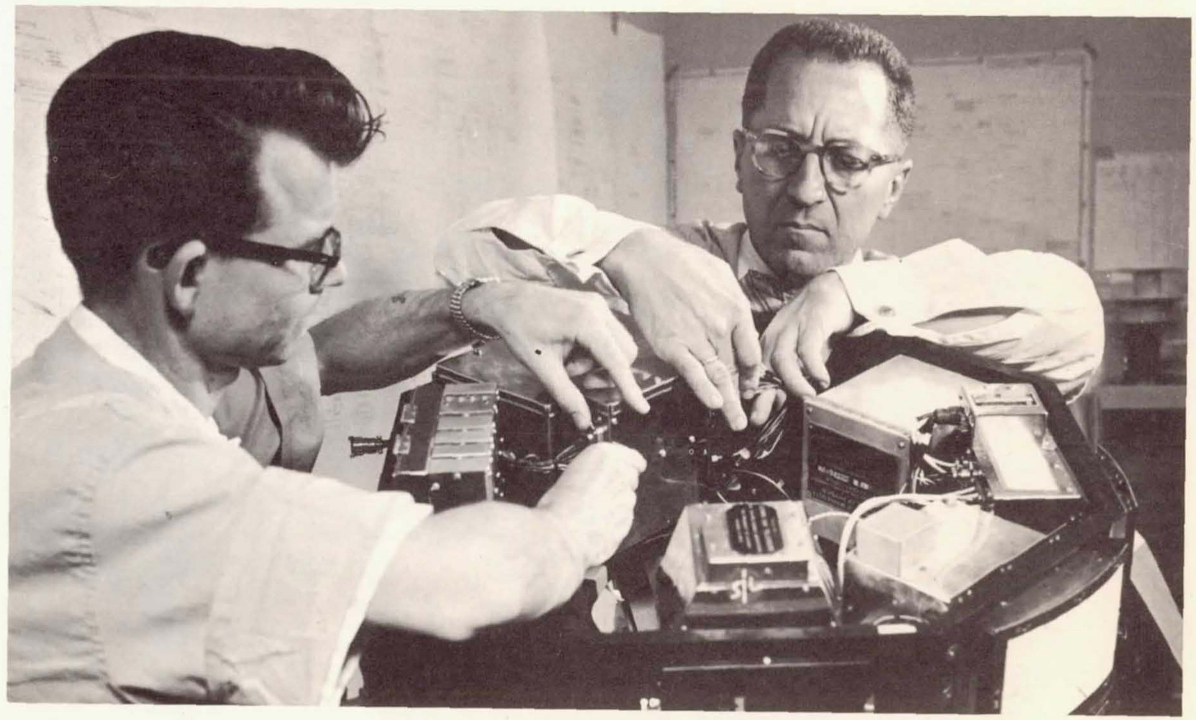
Almost from the beginning of the Space Age, United States spacecraft, with only automated instruments aboard, have been significantly advancing man's frontiers of knowledge and blazing a trail for eventual manned exploration of the moon and other celestial bodies. These spacecraft range from sounding rockets that travel a relatively few miles into space to Mariner II whose epic interplanetary voyage to the vicinity of Venus provided the world's first close observation of our mysterious neighbor planet.

This section portrays the space sciences spacecraft and their accomplishments, and the rocket vehicles that sent these spacecraft into orbit and beyond.

Vanguard II, first satellite launched by NASA, rests on the launch vehicle before being orbited on February 17, 1959. (First U.S. satellite was Explorer I, launched by Army on January 31, 1958. Vanguard I was launched by Navy on March 17, 1958. NASA orbited Vanguard III on September 18, 1959.)

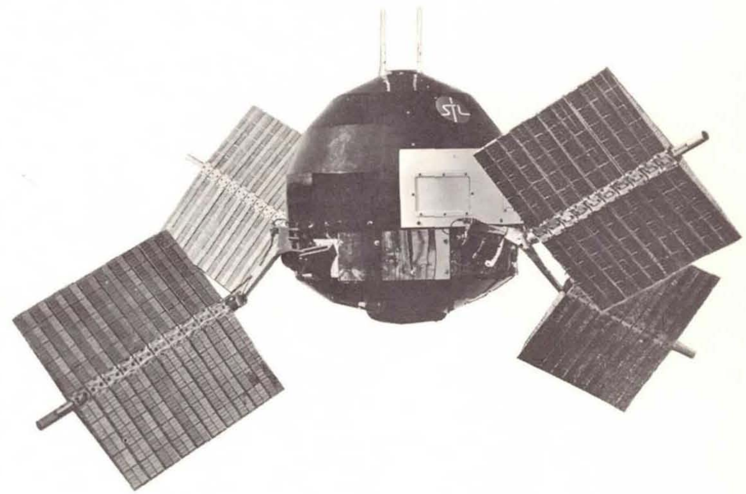


Explorer VI being checked prior to launch. This is the first satellite launched by NASA in the Explorer series.

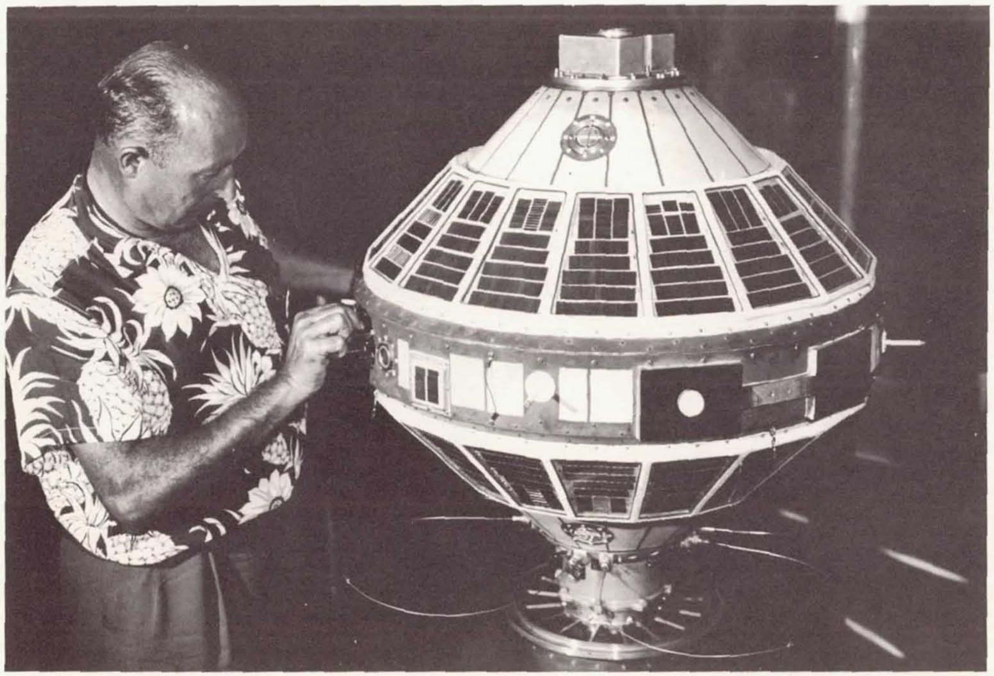


A Thor-Able launch vehicle orbited Explorer VI on August 7, 1959. Included in the satellite's equipment was a device capable of taking photographs.

Explorer VI with solar-cell panels extended as they would appear in orbit. The satellite mapped radiation and magnetic fields and transmitted the first picture of cloud cover ever sent by a satellite.



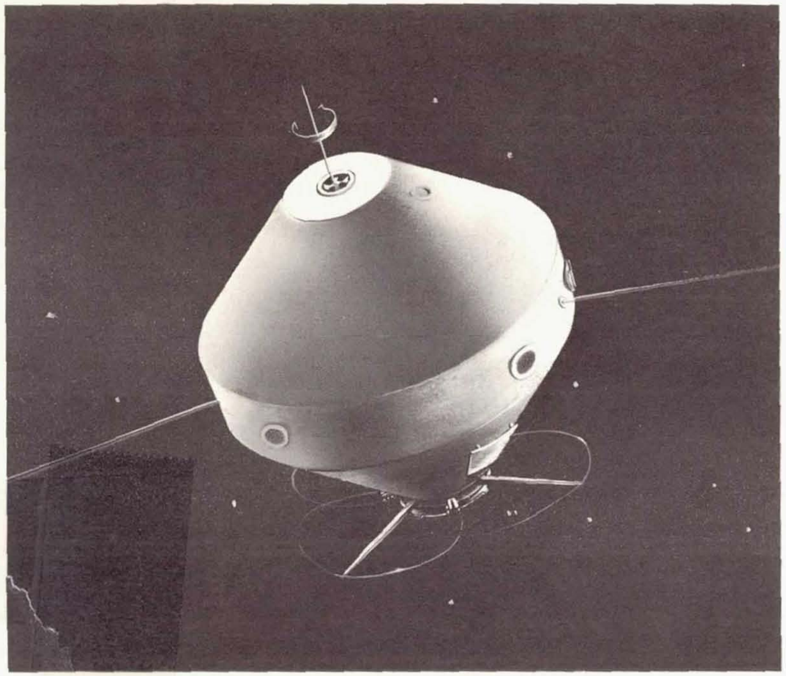
Technician prepares Explorer VII for launch on October 13, 1959. The satellite yielded information on radiation, magnetic fields, micrometeoroids (tiny particles of matter in space), and temperatures.



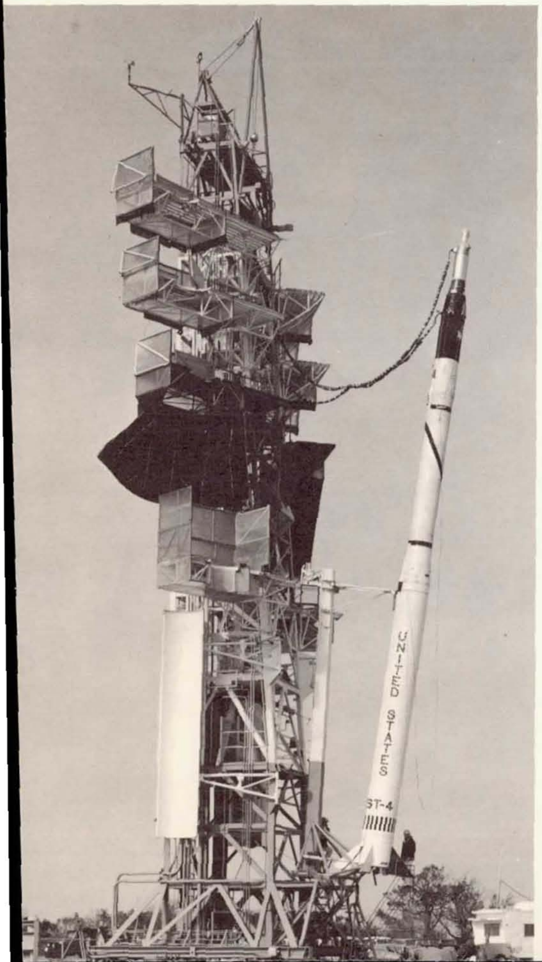
A Juno II booster, which like the Thor-Able was used in early NASA experiments, begins to rocket Explorer VIII into orbit on November 3, 1960.

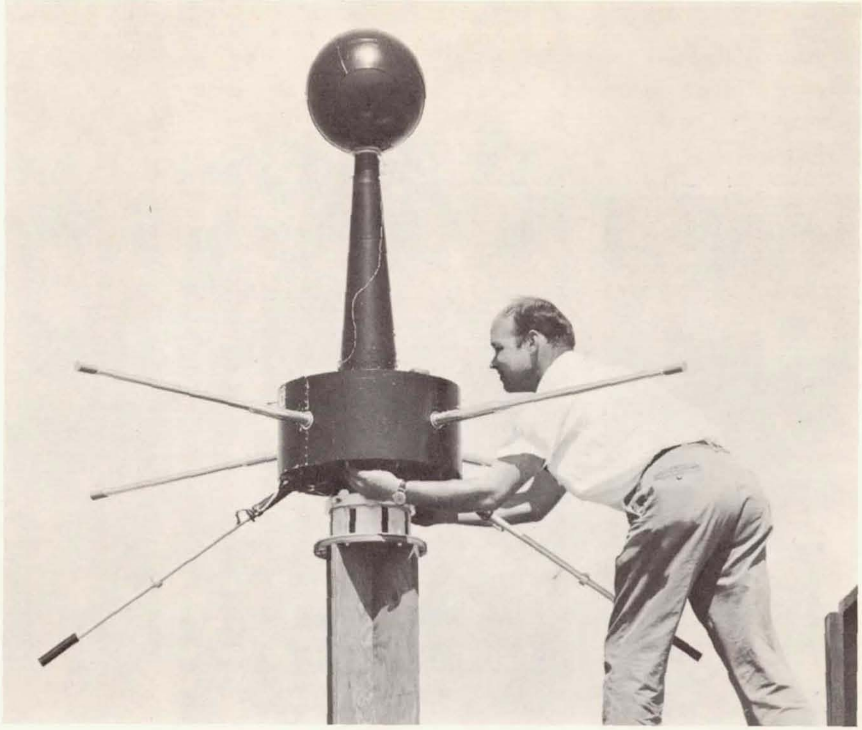
The 12-foot diameter Explorer IX, shown being inflation-tested, gathered data on density of the thin wisps of air at altitudes several hundred miles above earth and provided further evidence of the interaction of solar activity and the earth's atmosphere.

Explorer VIII. Among its discoveries was a layer of helium gas sandwiched in the earth's upper atmosphere between a lower region where oxygen predominates and an upper region constituted chiefly of hydrogen. The presence of this layer had not been known.



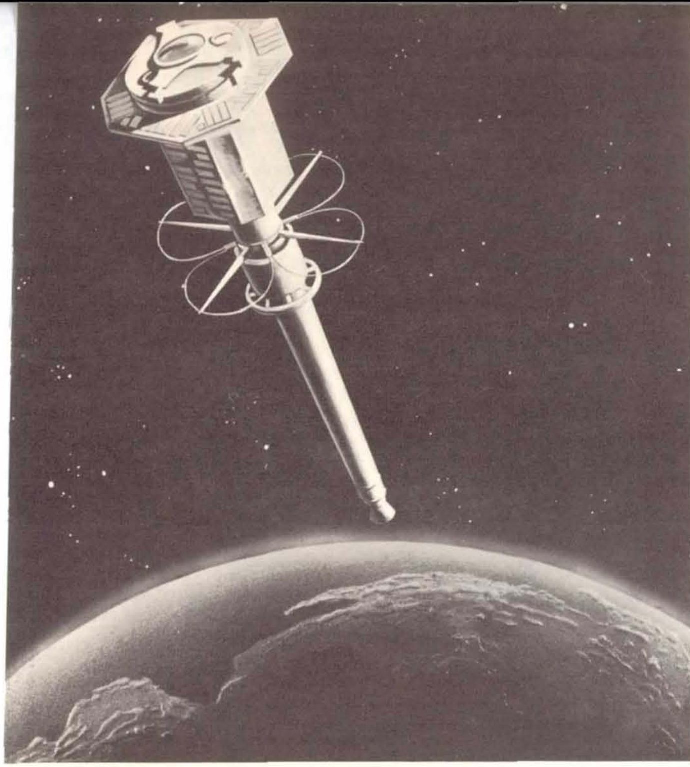
When NASA's Scout launch vehicle orbited Explorer IX on February 16, 1961, it marked the first launching of a satellite by an all-solid-fuel rocket.



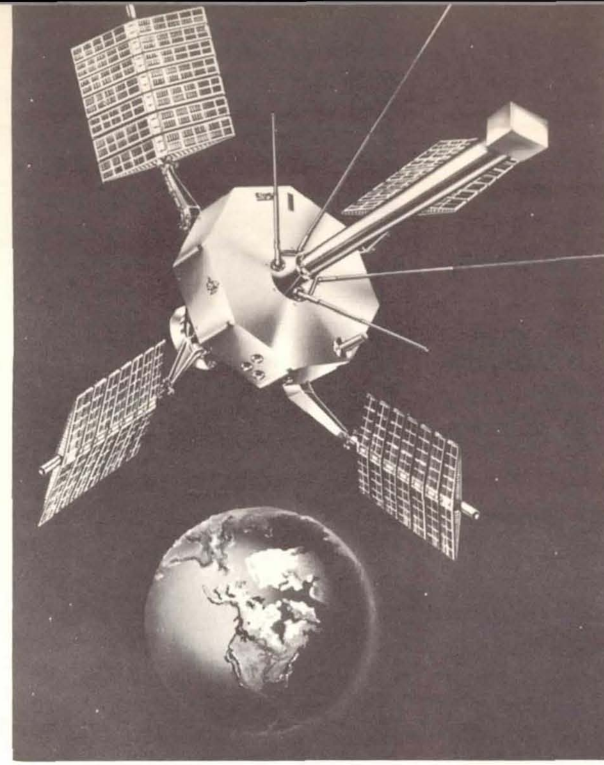


Technician works on Explorer X, launched March 25, 1961, which provided valuable data on earth's and interplanetary magnetic fields. Together with Explorer XII, Explorer X showed how the solar wind (hot electrified gases rushing from the sun) influences the size and shape of earth's magnetic field.

Juno II launches Explorer XI on April 27, 1961. Explorer XI was equipped to detect gamma rays streaming into the solar system from outer space as a step toward increasing understanding of the origin, evolution, and nature of the universe.



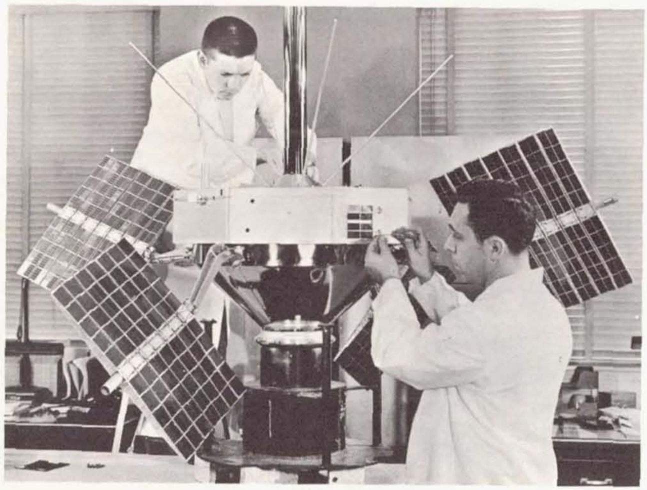
Explorer XI in space (artist's conception). Its data tends to contradict a theory that the universe is in a steady state; i.e., that matter is constantly being created and destroyed.



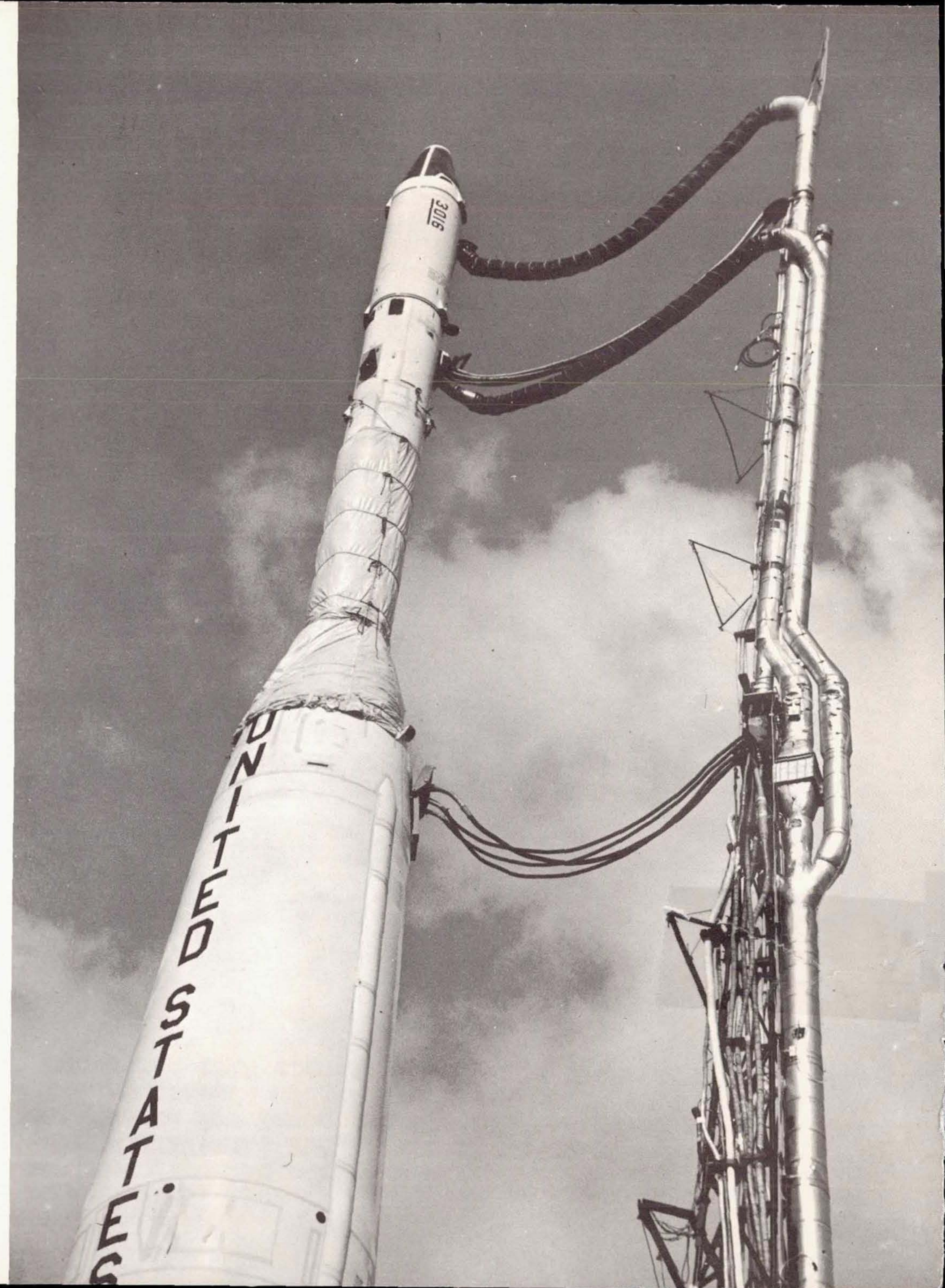
Energetic particles satellite, representative of Explorers XII, XIV, and XV. These satellites have mapped distribution of energetic particles (electrified atomic particles that constitute much of the radiation in space).

Check-out of Explorer XIV solar cells. Solar cells are photoelectric devices that convert sunlight to electricity for powering satellite instruments.

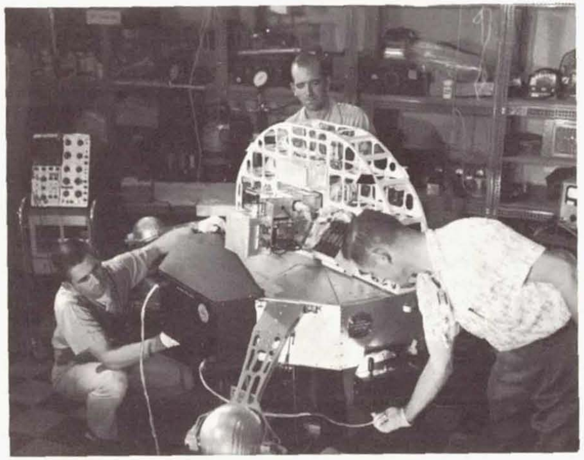
Technicians work on Explorer XII which indicated the correlation between the earth's magnetic field and the Van Allen Radiation Region, and the fact that the Region is a single area of charged particles of varying intensities instead of several belts. It also was shown that earth's magnetic field has a distinct outer edge instead of fading gradually into inter-planetary space.



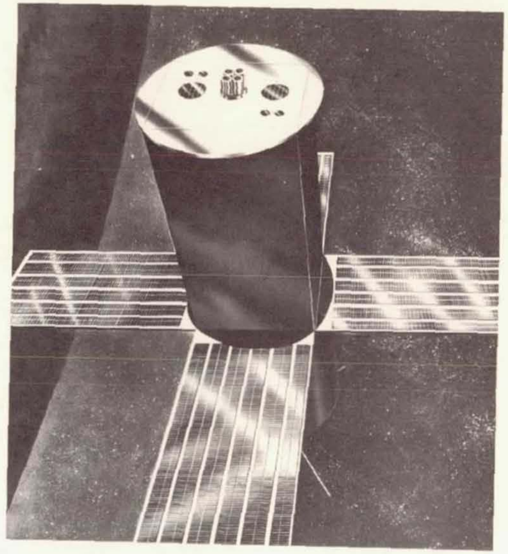
Delta poised to launch Explorer XV. Explorers XIV and XV have provided data on the artificial radiation belt created by the United States detonation of a hydrogen bomb above Johnston Island in the Pacific Ocean on July 9, 1962.



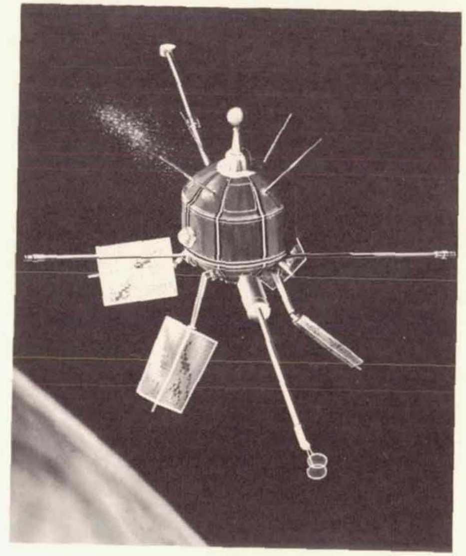
Engineers mate Explorer XVII to its Delta launch vehicle, a portion of which is visible at bottom. Orbited April 2, 1963, Explorer XVII has multiplied scientific data on atmospheric density, temperature, composition, and pressure.



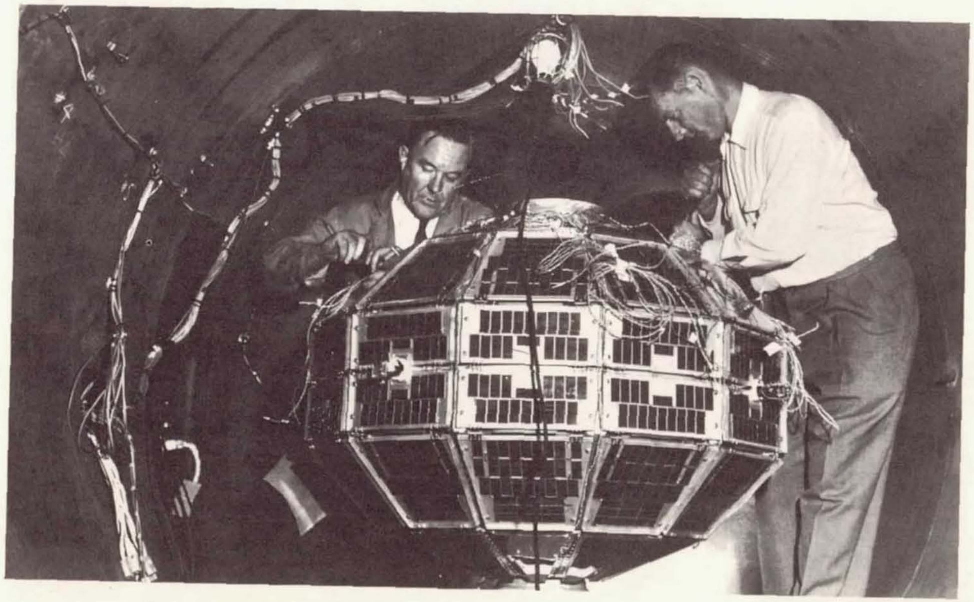
Orbiting Solar Observatory I is checked out prior to launch on March 7, 1962. The satellite has increased understanding of the sun's functioning and suggested that techniques can be developed for forecasting solar flares that peril man in space.



Artist's concept of Advanced Orbiting Solar Observatory under NASA development for deeper probing of the sun's secrets.

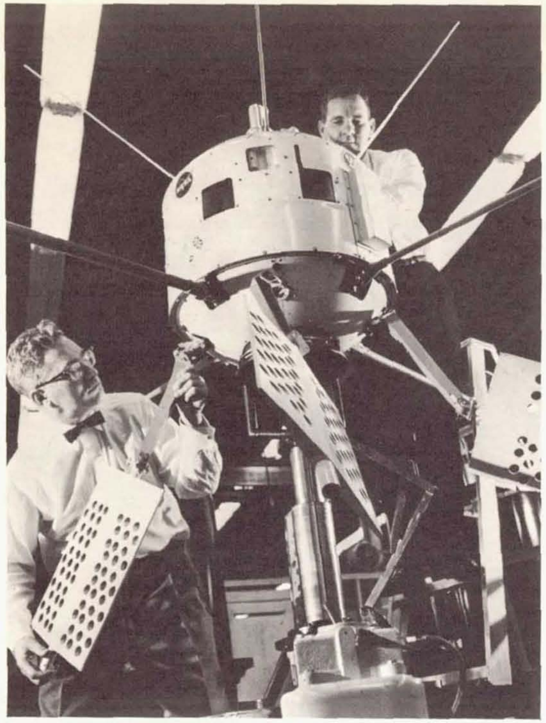


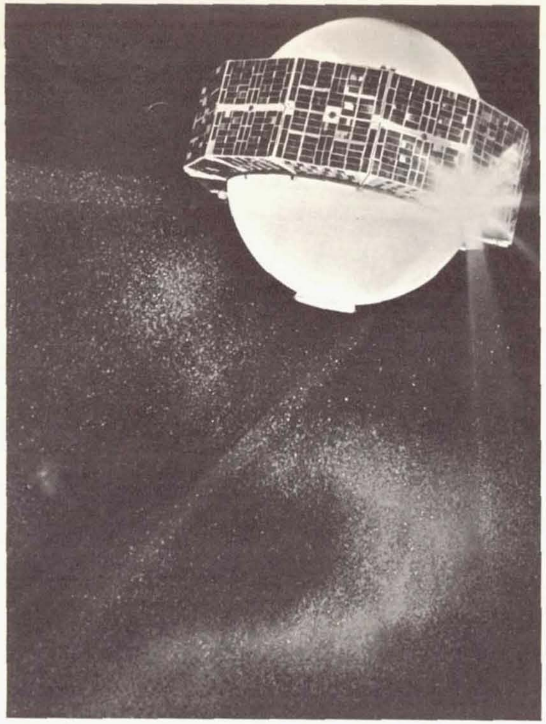
The world's first international satellite is Ariel, launched April 26, 1962. Structure, power, communications by U.S.; experiments by United Kingdom. Both Ariel and Alouette have contributed information about the ionosphere, an electrified portion of the atmosphere from which certain radio waves can be bounced for communication.



NASA has offered to launch satellites built by other nations or to include in its satellites experiments designed by foreign scientists. Alouette, built by Canada, was launched by NASA on September 28, 1962.

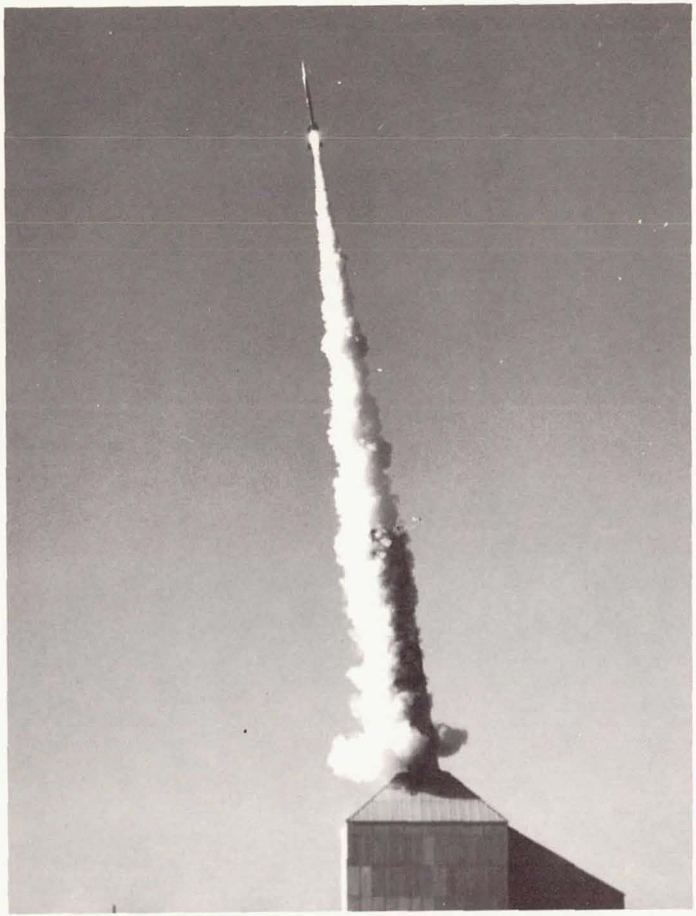
Engineers test model of second U.K.—U.S. satellite. A third is planned as are satellite experiments with other nations.



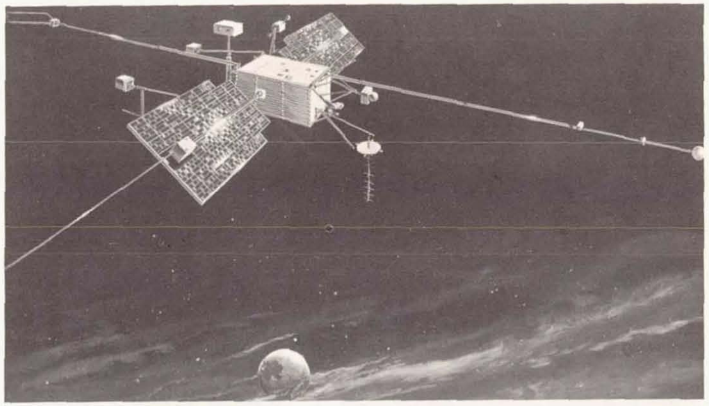


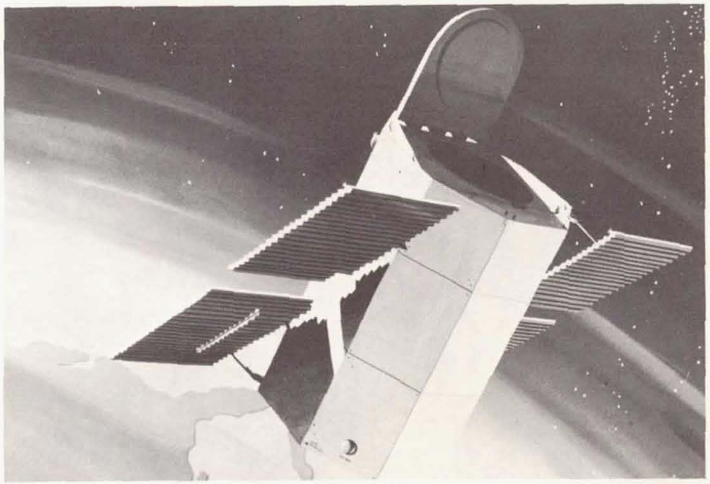
Artist's conception of ANNA IB, a joint project of the Army, Navy, NASA, and Air Force. It was launched October 31, 1962, to make measurements of the earth's size and shape and supply other geodetic data.

NASA sounding rockets have played an important role in scientific programs. A Nike-Cajun, employed chiefly in upper atmosphere experiments, is prepared for launch. Nike-Cajun is used in many international space science programs.



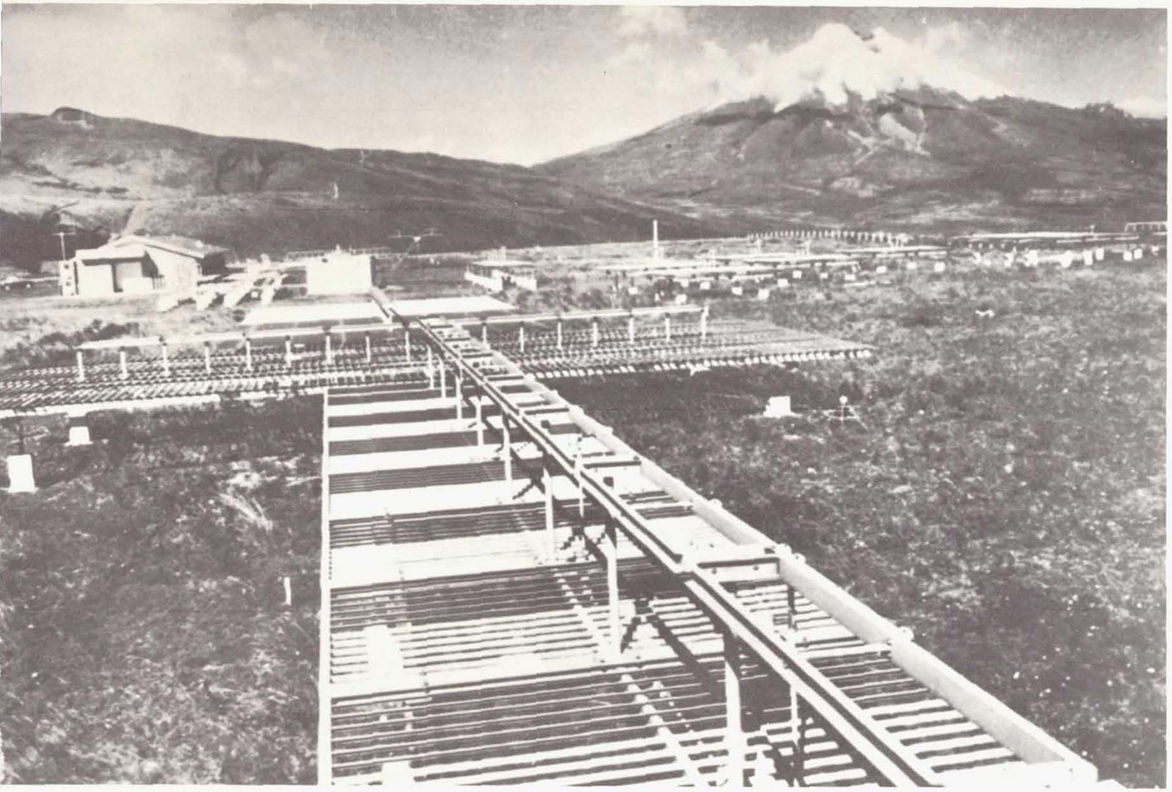
Aerobee sounding rocket is launched in zero gravity experiment.



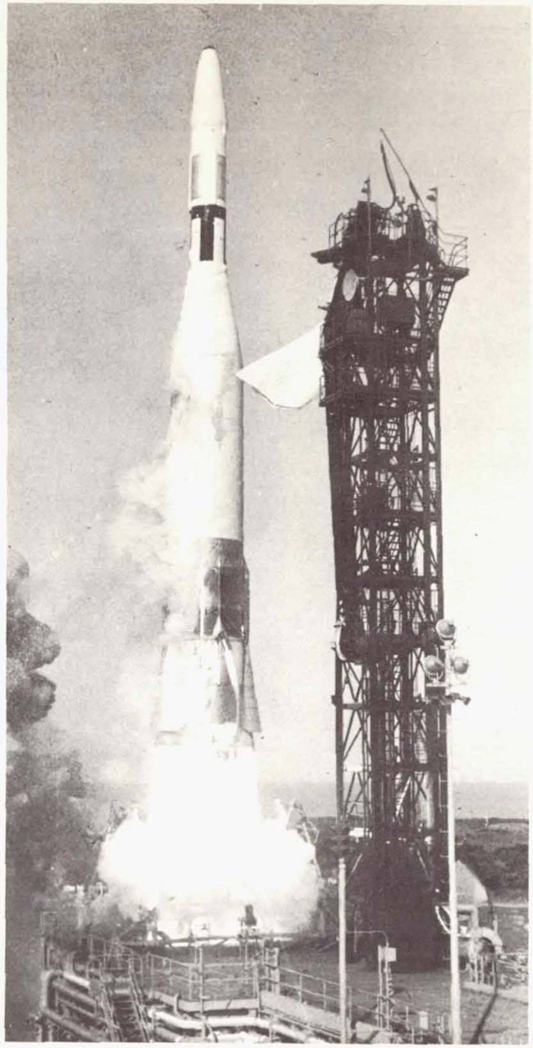


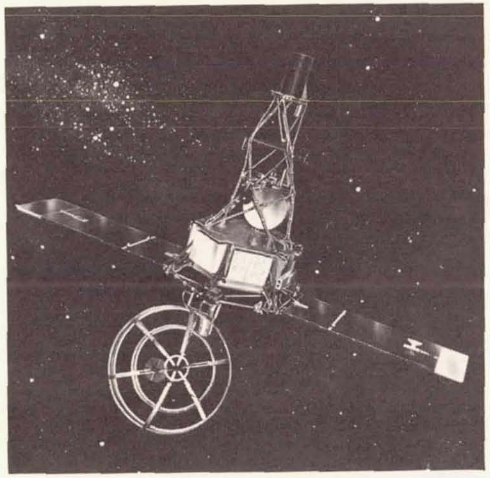
Artist's conceptions of two future satellites: Orbiting Geophysical Observatory (*above*) which will be able to conduct as many as fifty different geophysical and other scientific experiments, and the Orbiting Astronomical Observatory (*below*) that will enable astronomers to view the heavens from beyond the obscuring veil of earth's atmosphere.

Tracking antenna at Quito, Ecuador, part of the global Satellite Network with facilities and personnel of many nations that tracks and acquires data from satellites.



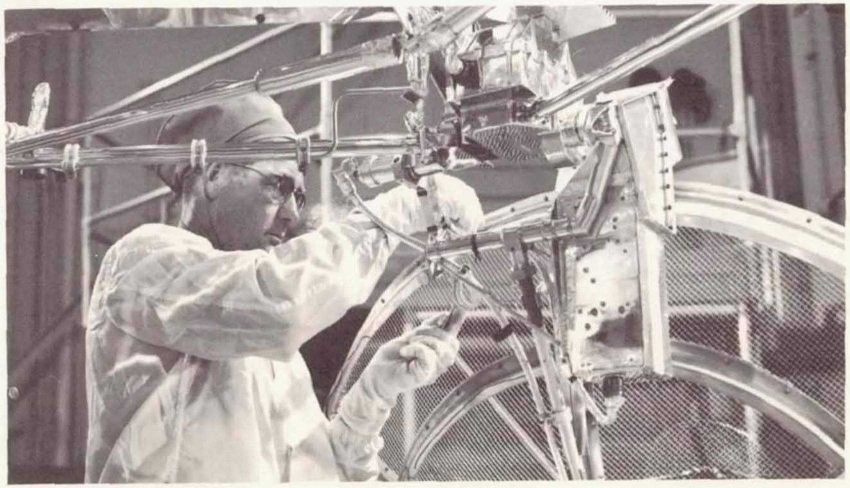
On August 27, 1962, an Atlas-Agena B booster launched NASA's Mariner II spacecraft on one of the most productive missions in the history of space exploration.



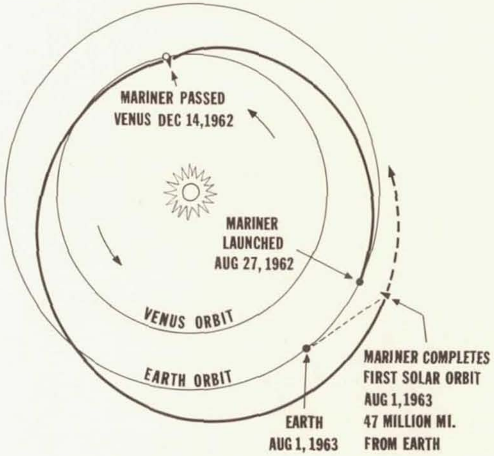


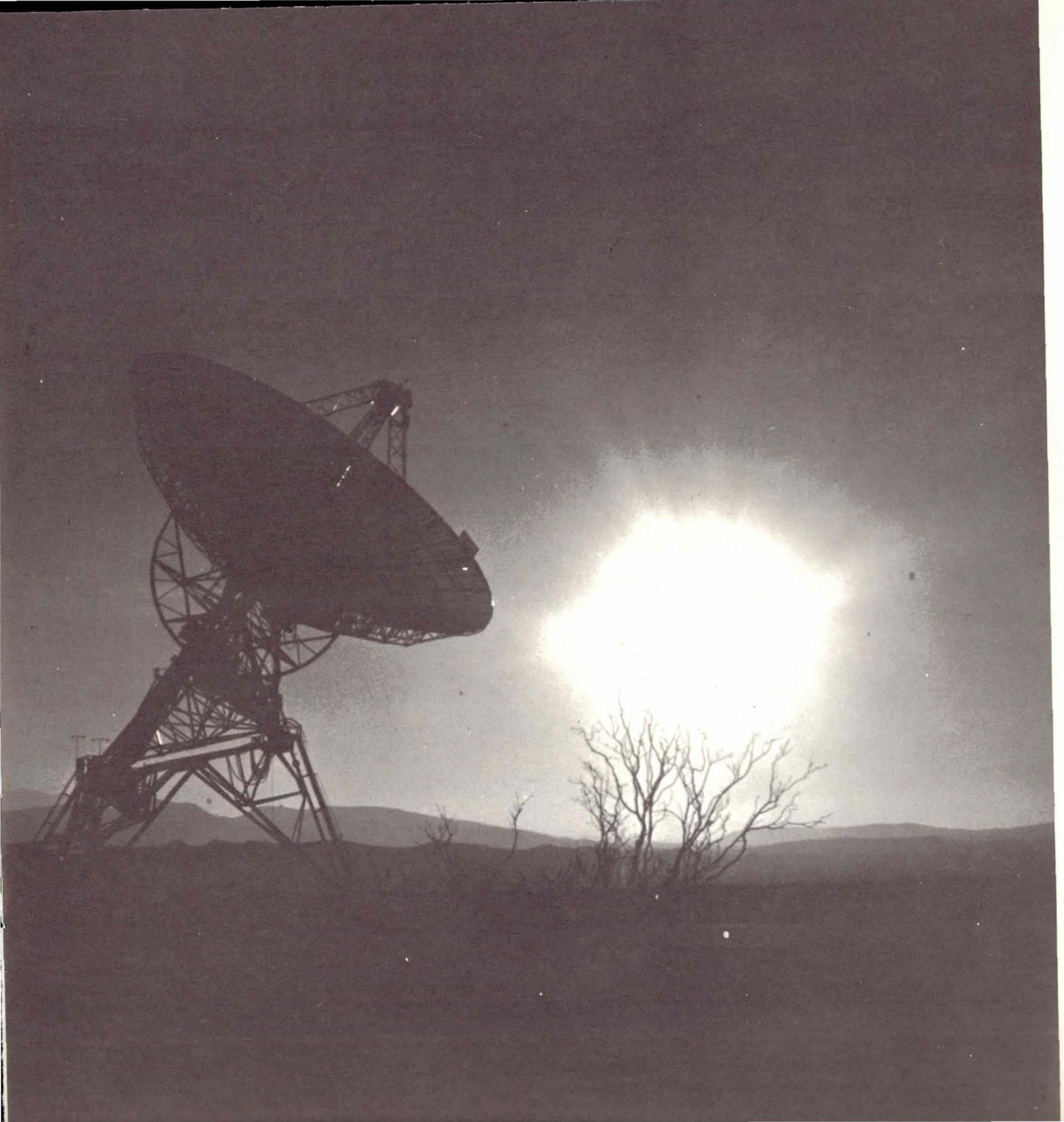
Viewing Venus from as close as 21,648 miles, Mariner II revealed among other data that the planet's surface temperature may be as hot as 800° Fahrenheit and that the 15-mile thick bank of clouds shrouding the planet has temperatures from 200° at the base to −60° at the upper level.

Technician works on Mariner II antenna that maintained contact with earth until January 3, 1963 when Mariner was 53.9 million miles away—a communications record.

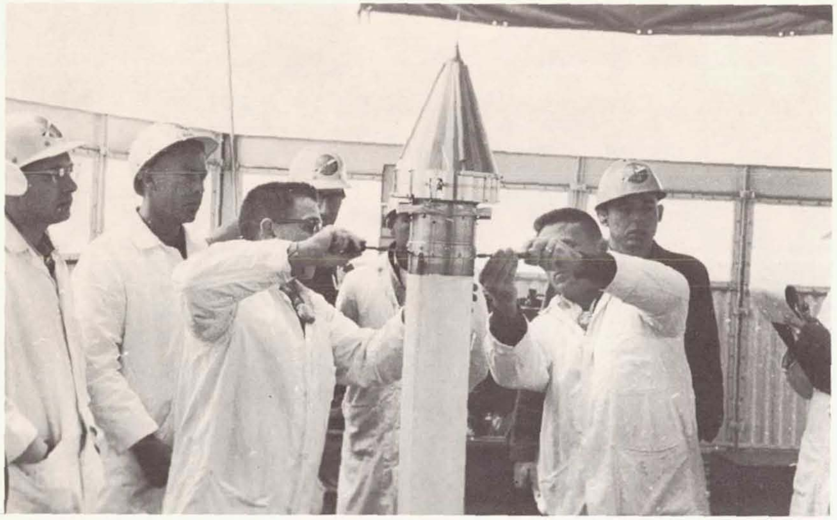


On August 1, 1963, Mariner II completed its first solar orbit. Mariner II has provided substantial data on radiation and magnetic fields in interplanetary space and augmented knowledge about the solar wind, hot gases rushing millions of miles into space from the sun's turbulent surface.

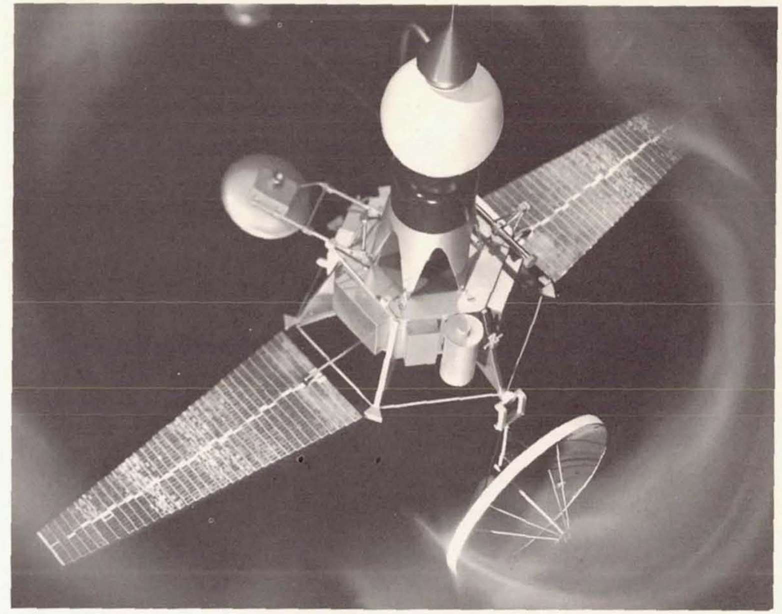




A global network of giant 85-foot diameter antennas like this one at Goldstone, Calif., maintained contact with Mariner during its multi-million mile flight.

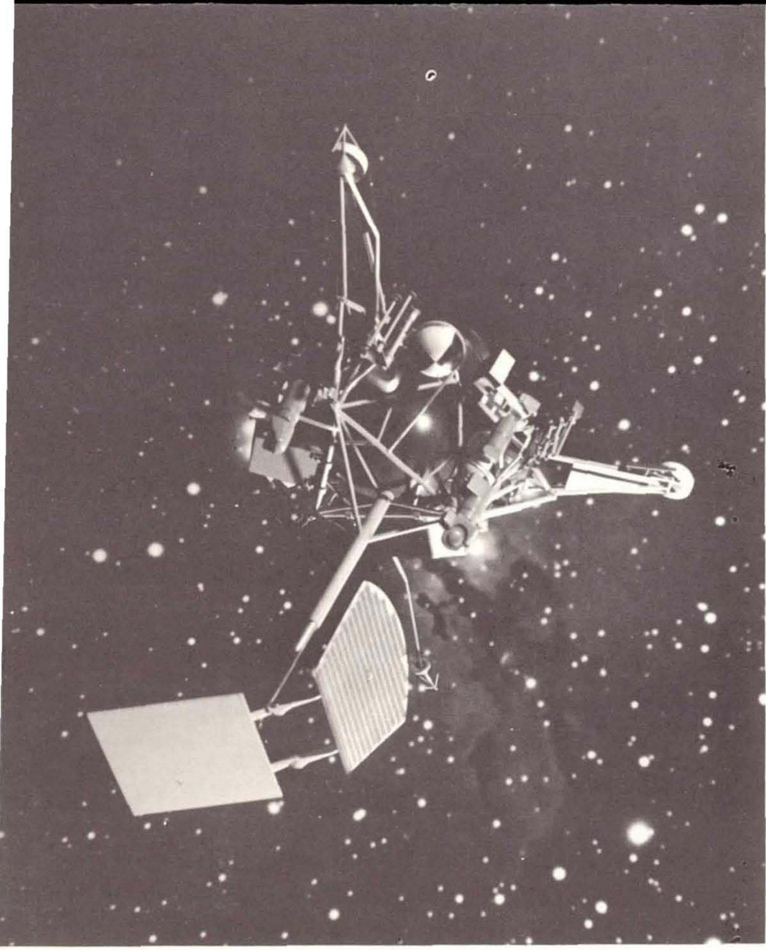


Among the NASA spacecraft that have preceded Mariner II into solar orbit is Pioneer IV. Here the cone-shaped craft is installed on its Juno II booster prior to launch on March 3, 1959.

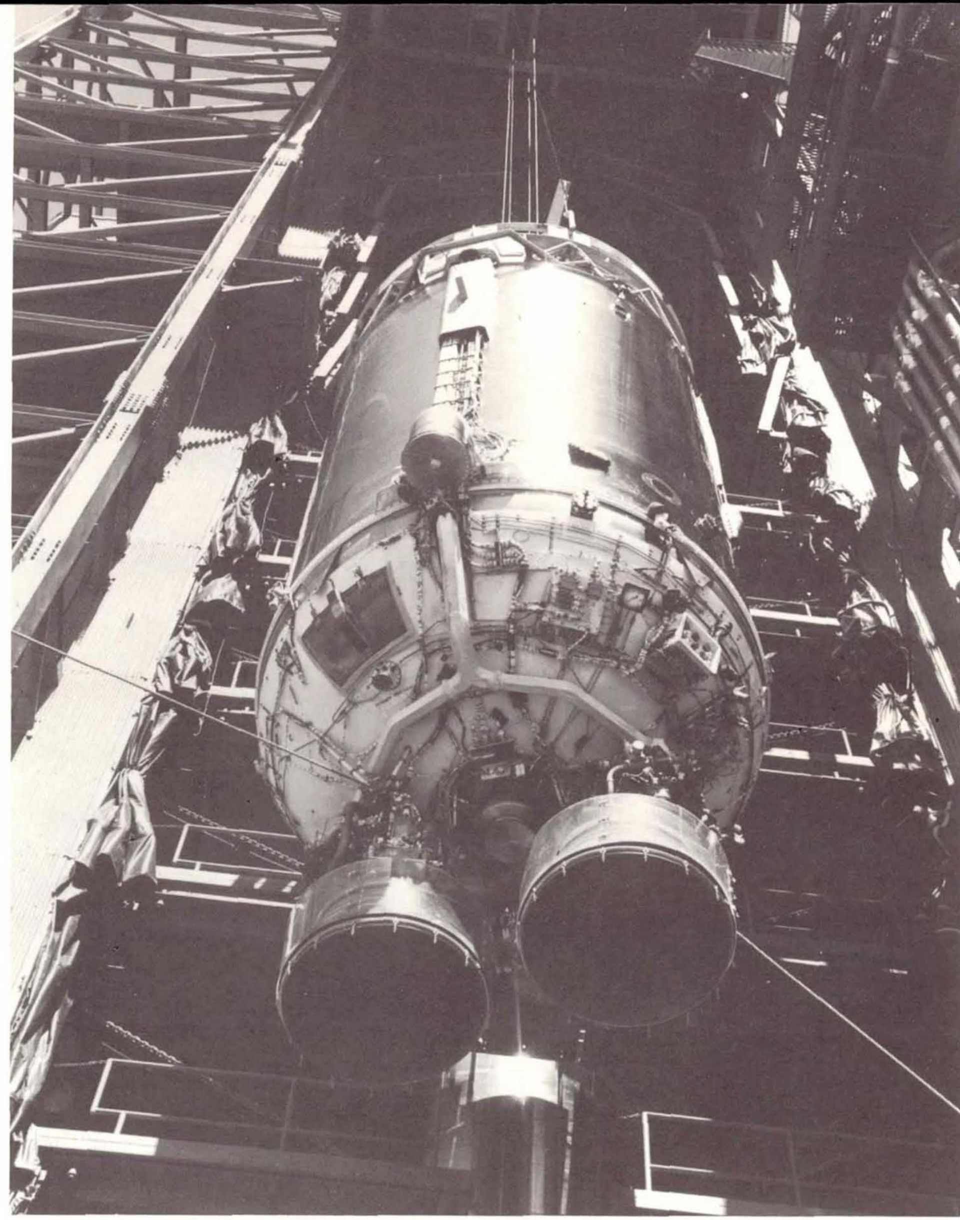


Ranger III and V, designed to provide lunar data and pictures before crashing on the moon, missed their target and went into solar orbit. Ranger IV hit the moon but sent no useful information because its radio had died. Plans call for additional Ranger launchings.

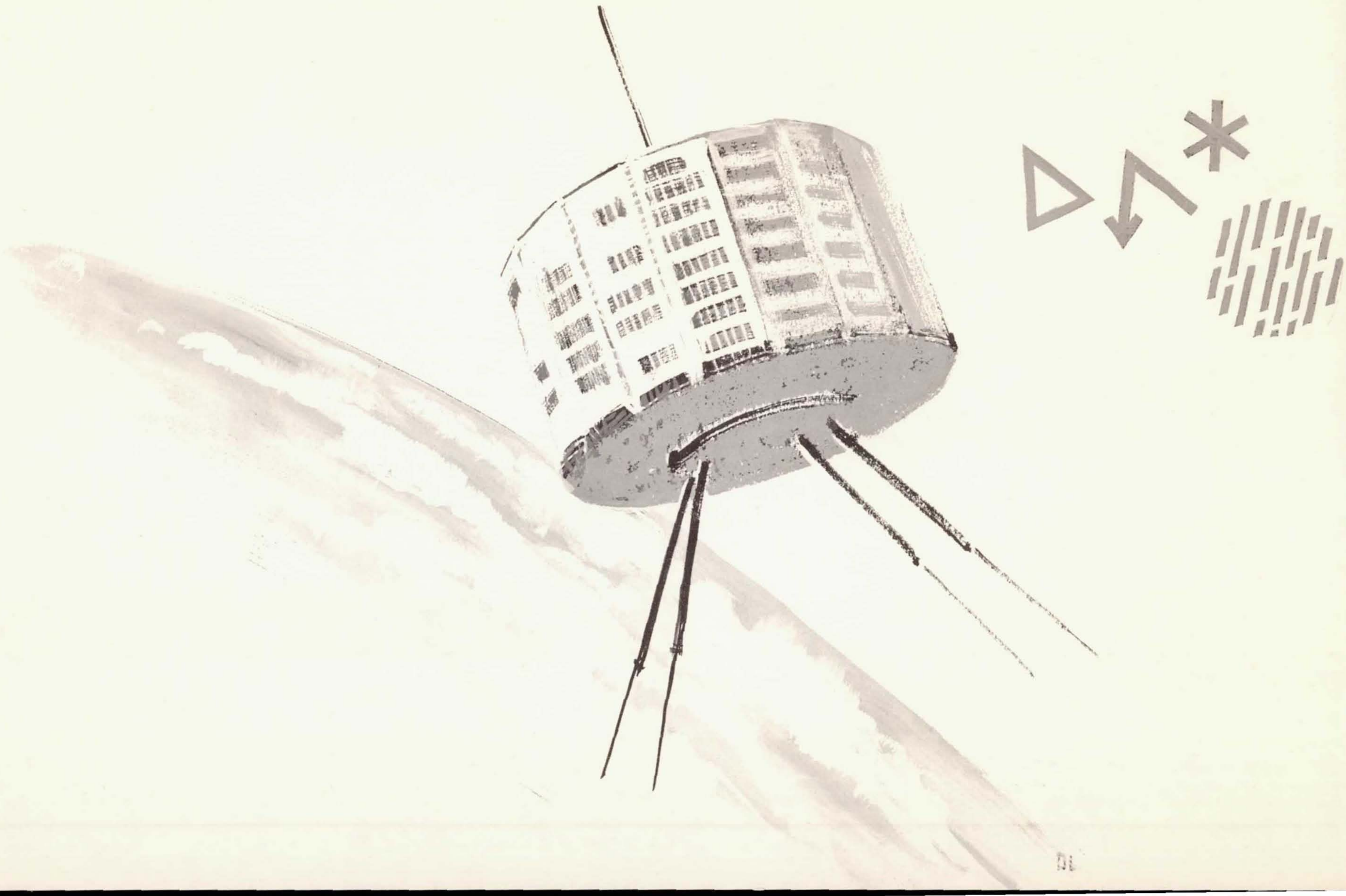
Another is Pioneer V, launched March 11, 1960. Until the Mariner II experiment, Pioneer V held the world record for long distance communications—22.5 million miles. NASA plans another series of Pioneer craft to gather data on interplanetary space.

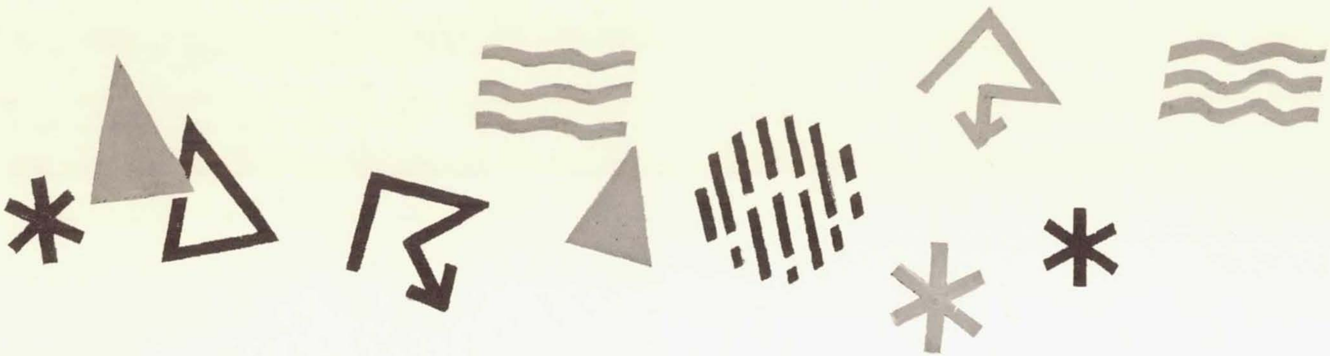


Artist's conception of Surveyor craft under development that will land gently on the moon and return lunar data, including pictures, to earth. Another kind of Surveyor will go into lunar orbit and send information. Advance information about the moon is vital to preparation for manned exploration.



Centaur—the upper stage of the Atlas–Centaur launch vehicle—is being raised in the gantry. Fueled with high-energy liquid hydrogen, Centaur is in development for lunar and interplanetary missions. A successful launch from Cape Kennedy in November, 1963, put a 10,200-pound Centaur casing into orbit around the earth.





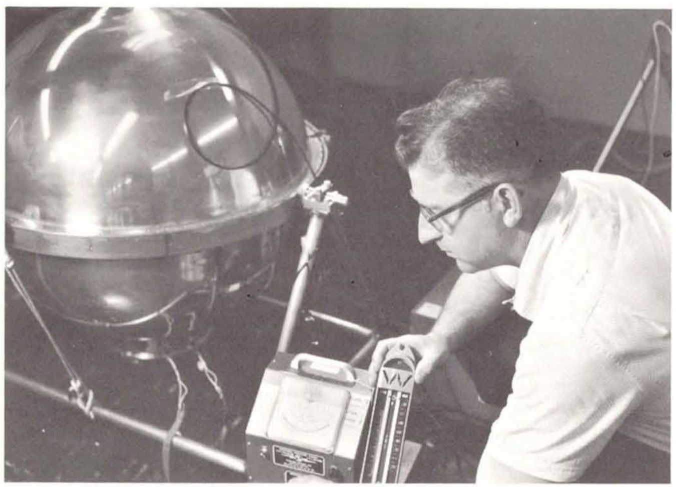
APPLICATIONS PROGRAM PUTS SPACE TECHNOLOGY TO PRACTICAL USE

Very substantial progress in development of satellite systems for communications and weather forecasting has been made in the first five years of the civilian space program. In its communications satellite projects, NASA has demonstrated the feasibility and potential of a communications satellite network for vastly increasing global communications circuits to meet rapidly mounting demands. In meteorology, NASA's TIROS satellites have won acclaim from world weather services for the clarity of cloud pictures and other data they provide. The increased observation of global weather conditions made possible by TIROS is already contributing to accuracy in weather forecasts. Moreover, TIROS has furnished valuable information on snow cover, for use in predicting spring flooding, and on river and sea ice.

The progress in weather and communications satellite development is reflected in the illustrations that follow.

A floodlit Delta poised on a launch pad at Cape Canaveral, Fla., to hurl the historic Echo I satellite into orbit on August 12, 1960.

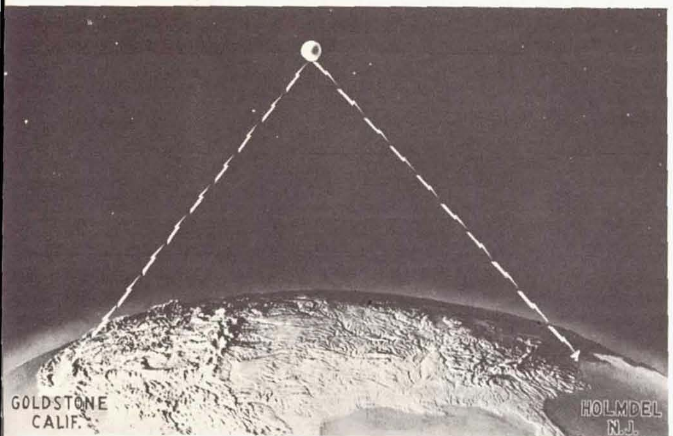
A communications satellite functions as a radio station for relay of ultra high-frequency (UHF) radio signals, in the same manner as this microwave tower on lonely Buckhorn Mountain in Colorado.

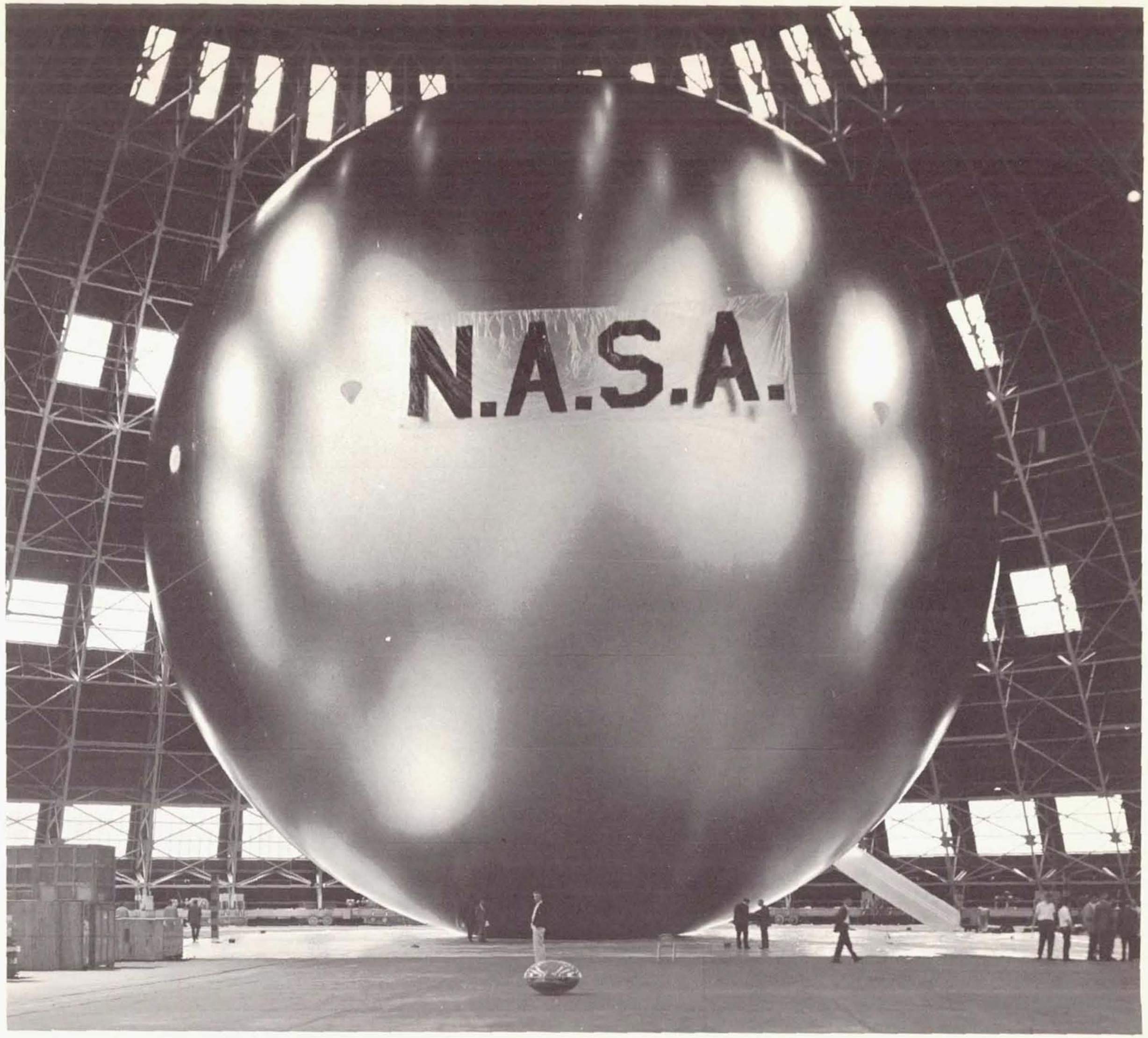


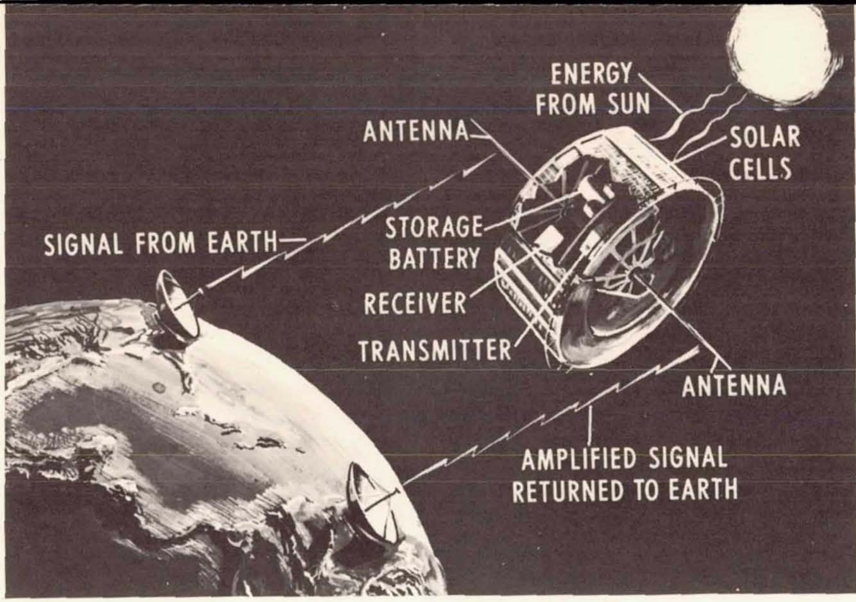
At launch, Echo I was folded inside this 26-inch diameter canister, shown being checked by a technician. In orbit, Echo I unfolded and inflated to a 100-foot diameter.

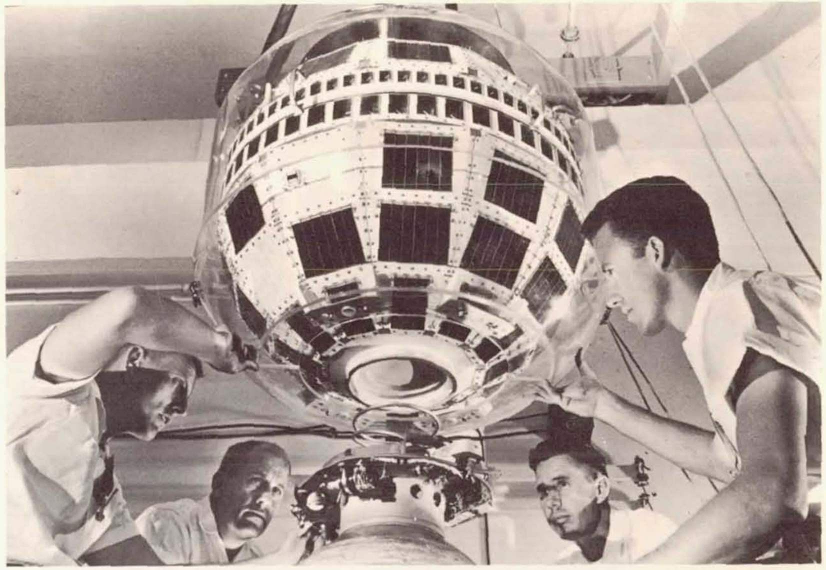
Voice and still photograph transmissions were sent via Echo I between Bell Laboratories in Holmdel, N.J., and NASA's Jet Propulsion Laboratory facility at Goldstone, Calif.

The successor to Echo I is shown during ground inflation test. Note launching container in foreground. The new Echo, 135 feet in diameter and 20 times the rigidity of Echo I, was rocketed into orbit on January 25, 1964.





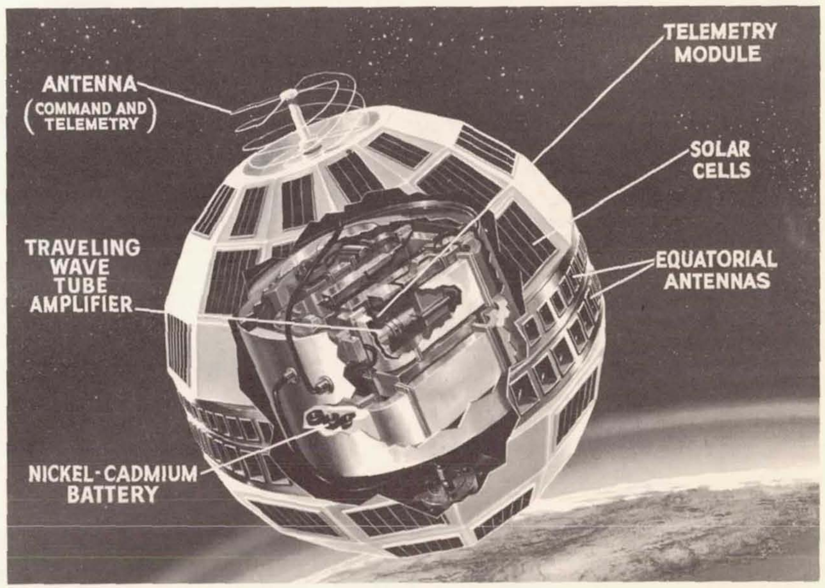




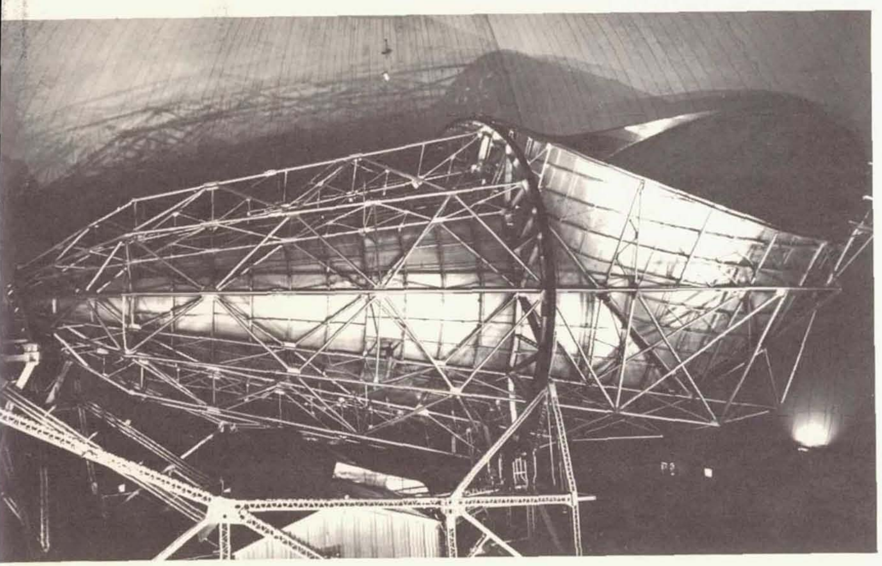
Unlike passive satellites, such as Echo, that only reflect radio signals, active-repeater satellites are equipped to receive, amplify, and transmit radio signals (*upper left*).

Telstar I is checked prior to launch July 10, 1962 (*upper right*). Telstar satellites, a cooperative project of NASA and the American Telephone and Telegraph Company, are financed by the company.

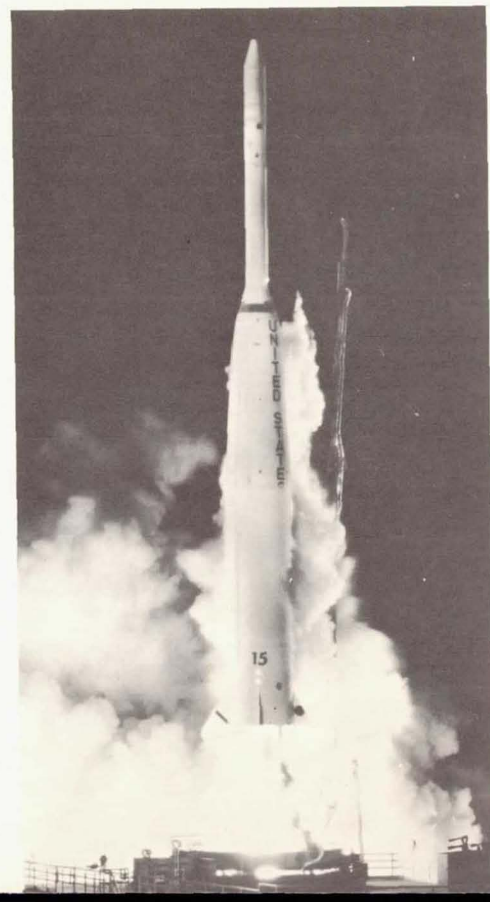
Major components of Telstar I (*lower right*). On July 23, 1962, the satellite relayed the first live telecast between Europe and the United States. A second Telstar was launched May 7, 1963.



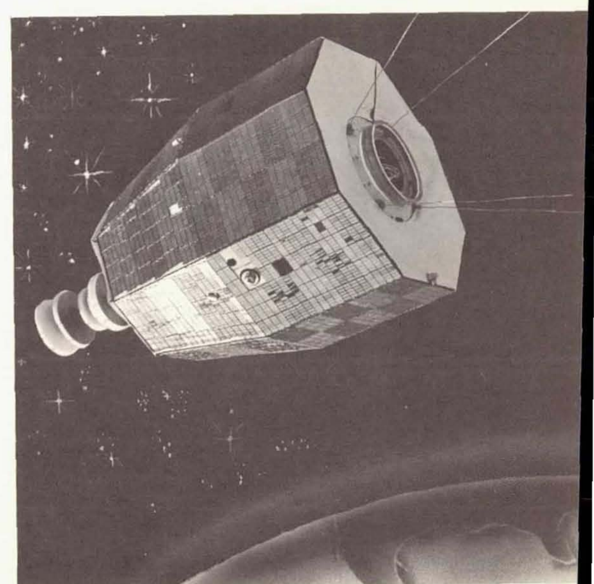
Giant horn antenna at Andover, Maine, one of several used in communications experiments. It can scoop up and amplify to useful strength radio signals of less than a billionth of a watt. Note man on support (*center of photo*).



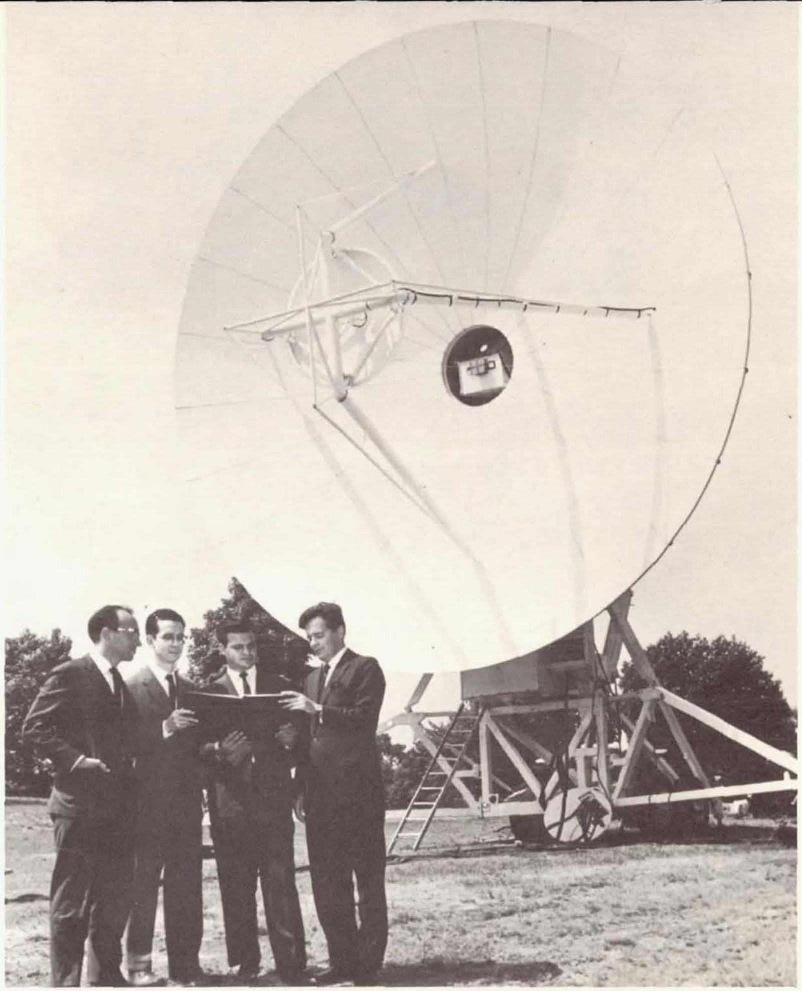
Delta launches Relay active-repeater satellite. Deltas orbited Relay I on December 13, 1962 and Relay II on January 21, 1964. With the successful orbit of Relay II, this launch vehicle had operated flawlessly 22 consecutive times.



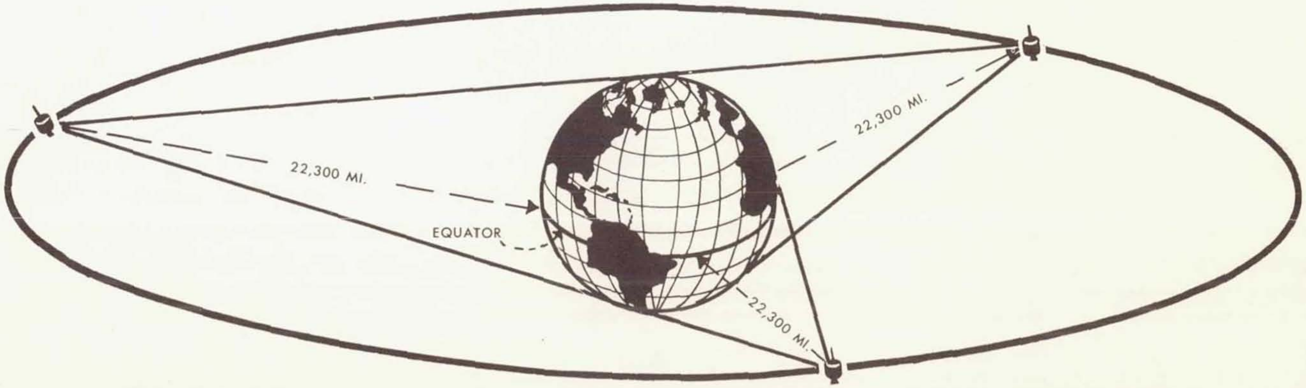
Relay in space (artist's conception). Relay differs from Telstar in important structural and design features and orbiting of both permits comparison of the different designs and acquisition of information for development of equipment for eventual operational satellite systems.

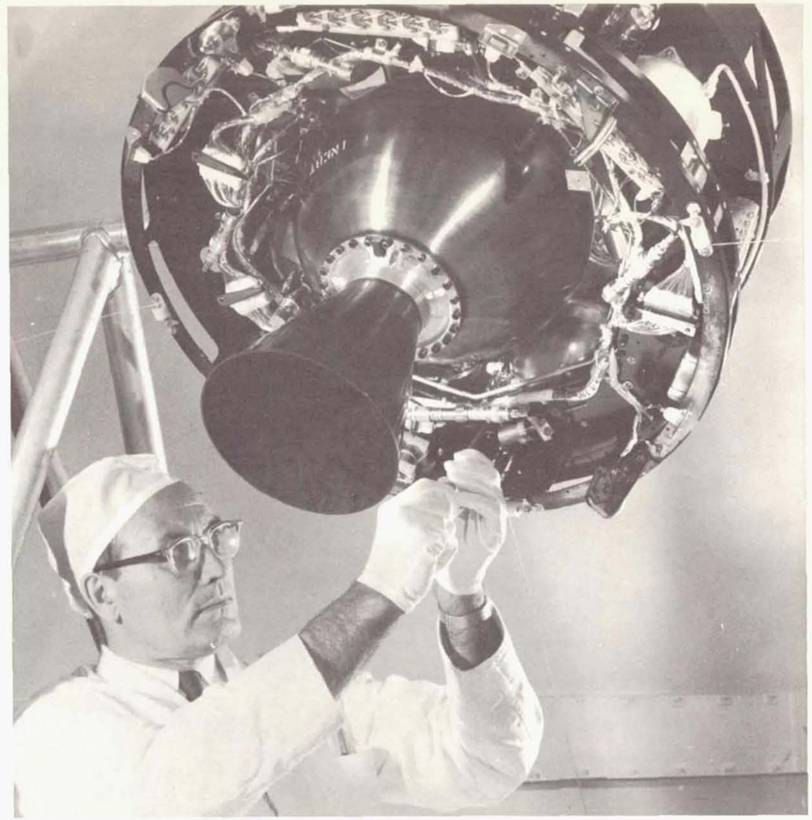


Many nations have participated with the United States in communications satellite experiments. Here, Brazilian engineers plan Relay experiment at ground station near Rio de Janeiro.



Three fixed synchronous active-repeater satellites, equidistant around the equator, could provide global coverage. Such satellites are in orbits at a 22,300-mile altitude parallel to the equator. They appear fixed relative to a point on earth because they take as long to go around the globe as the earth takes to rotate on its axis.



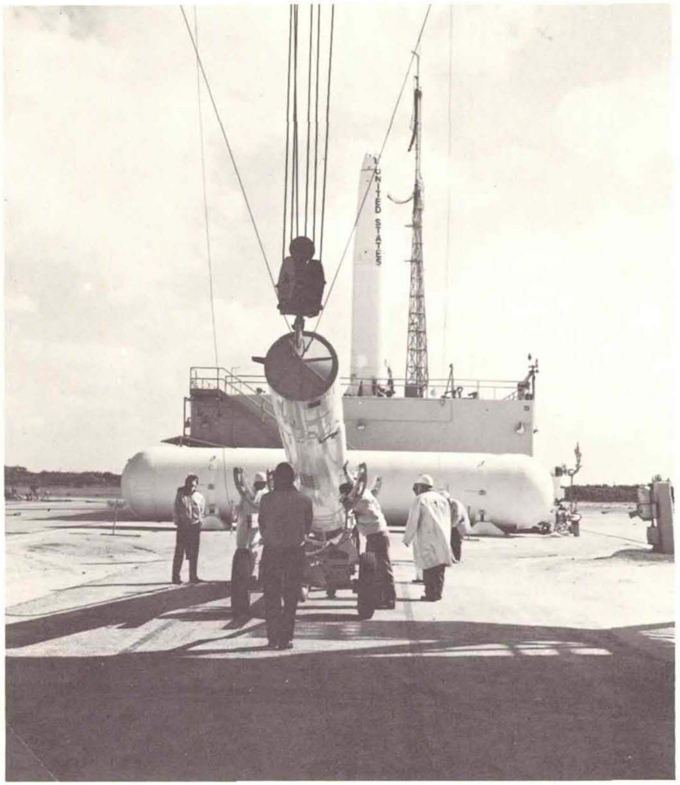


A technician checks Syncom (*left, above*), the experimental satellite used in the United States space project that could lead to a synchronous system.

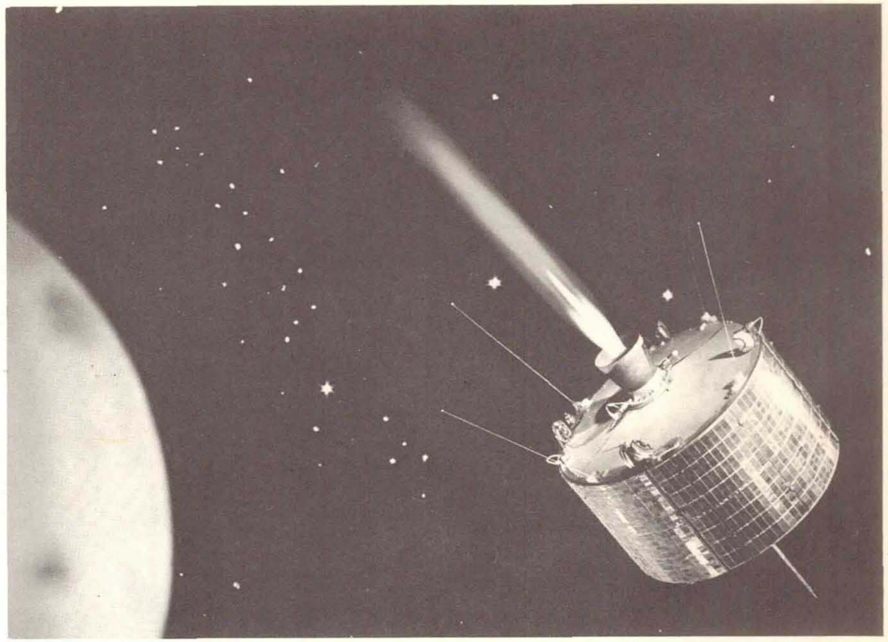
Another view of Syncom (*right*) featuring the apogee rocket. This rocket "kicks" the satellite from the highest point in its original elliptical orbit into a near-synchronous orbit.

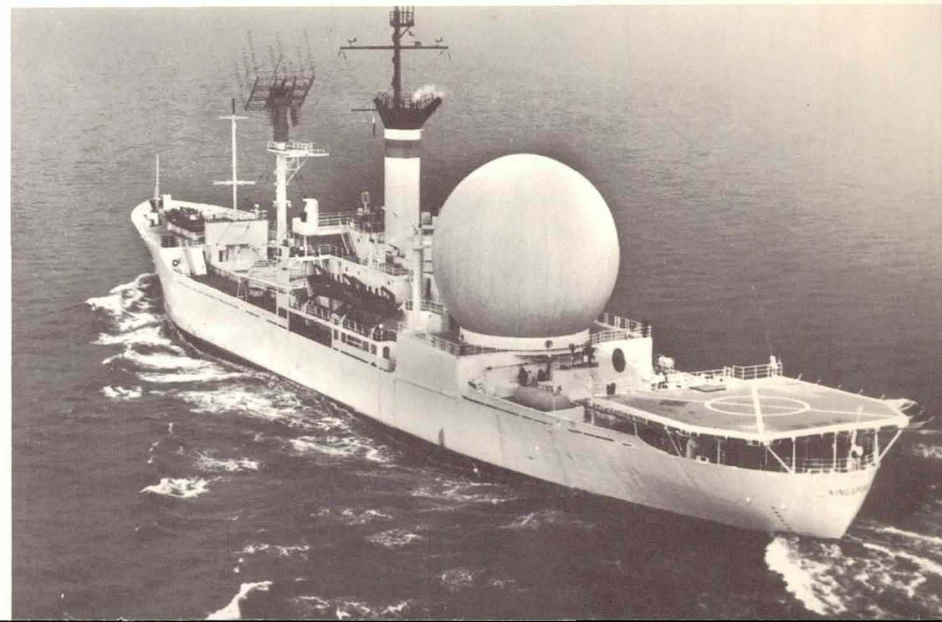
Second stage of Delta is hoisted to mate it with first stage on launch pad in background (*below*).

Lower right: A 30-foot diameter antenna for Syncom communications experiment is housed in radome on USNS Kingsport, anchored in the harbor of Lagos, Nigeria. Communications experiments with Syncom II have demonstrated feasibility of communications satellites at synchronous altitude. (Contact with Syncom I was lost at apogee motor firing.)

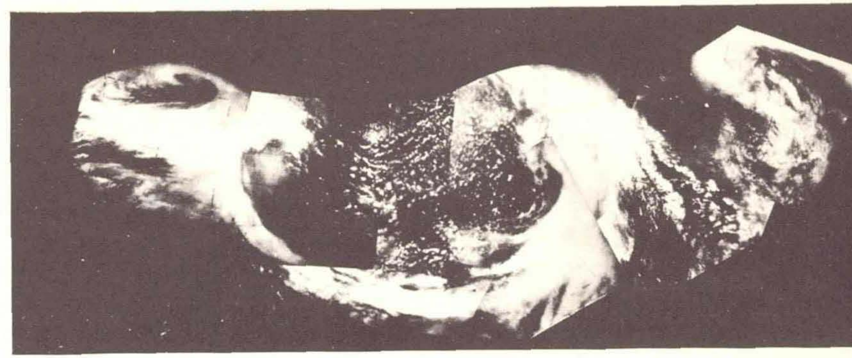


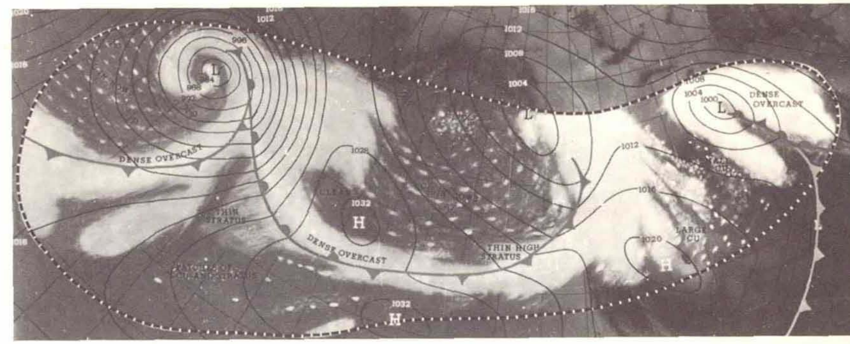
Syncom with apogee rocket firing (artist's conception). Syncoms I and II, launched February 14 and July 23, 1963, respectively, are in orbits that cross rather than parallel the equator. Therefore, they move north and south relative to the earth's surface instead of remaining over one spot.

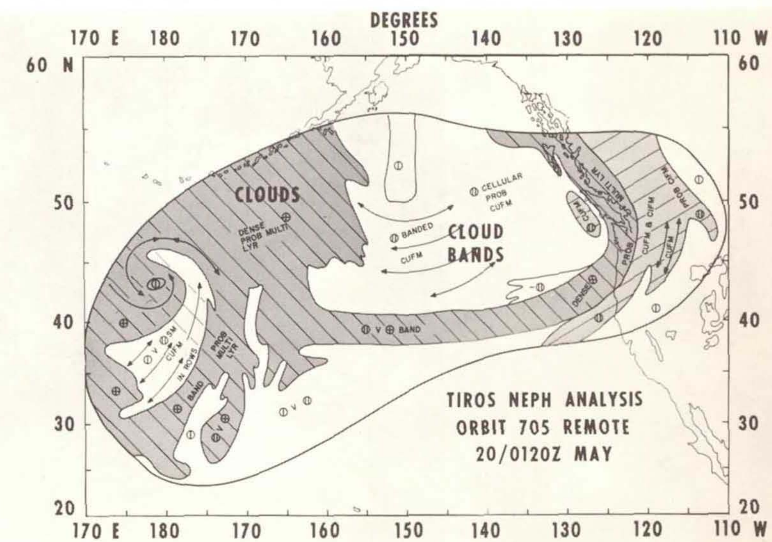




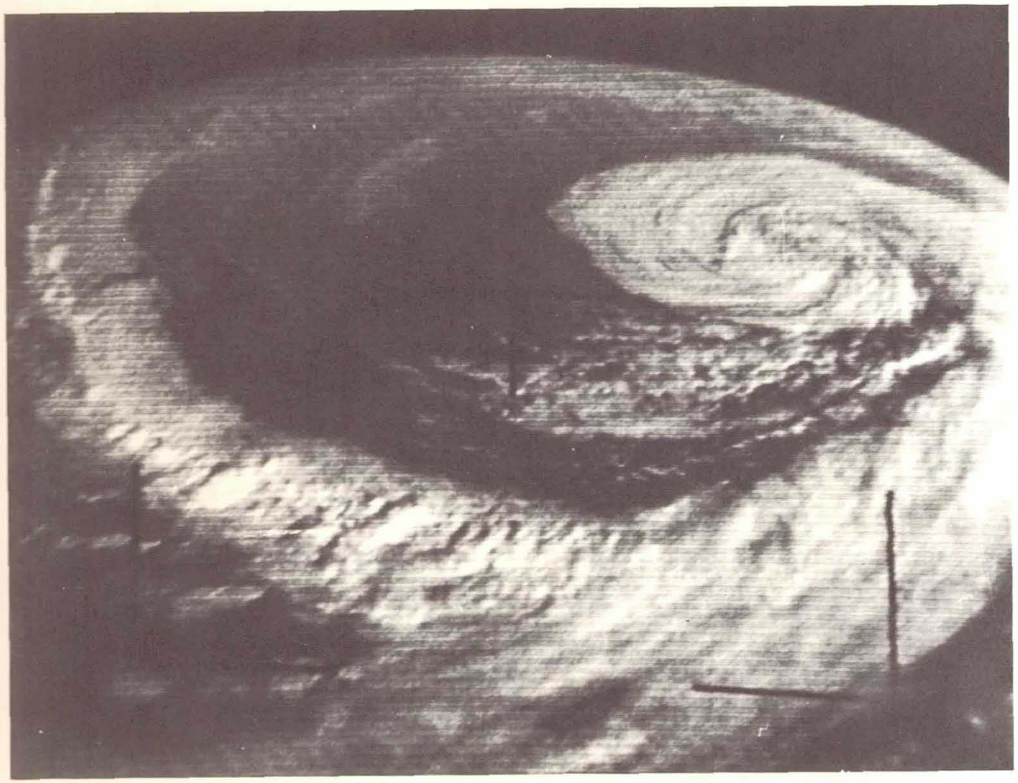
How cloud pictures become weather charts: Information from a mosaic of TIROS cloud pictures (*upper right*); is overlaid on map (*center right*); and reduced to operational data for weather services (*lower right*).

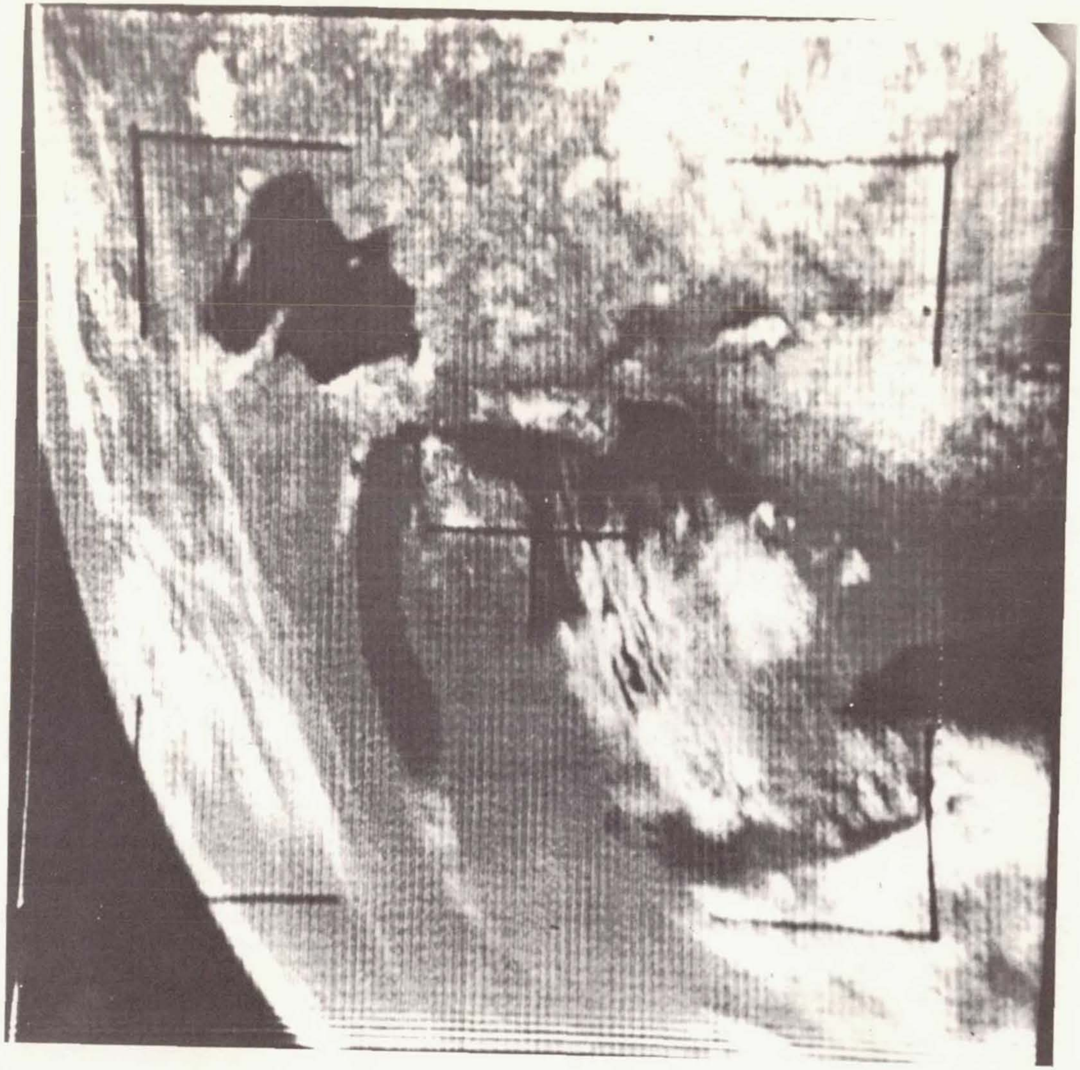




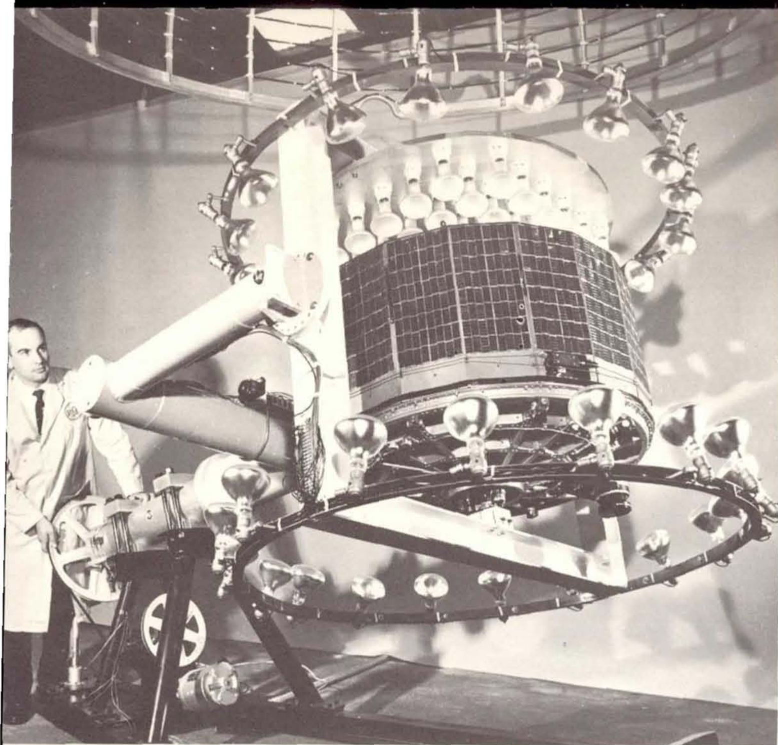


Vortex (storm) near Nova Scotia taken by TIROS VI on May 29, 1963 (*below*). It is one of thousands of cloud pictures that have helped world weather services to increase the accuracy of their forecasts.



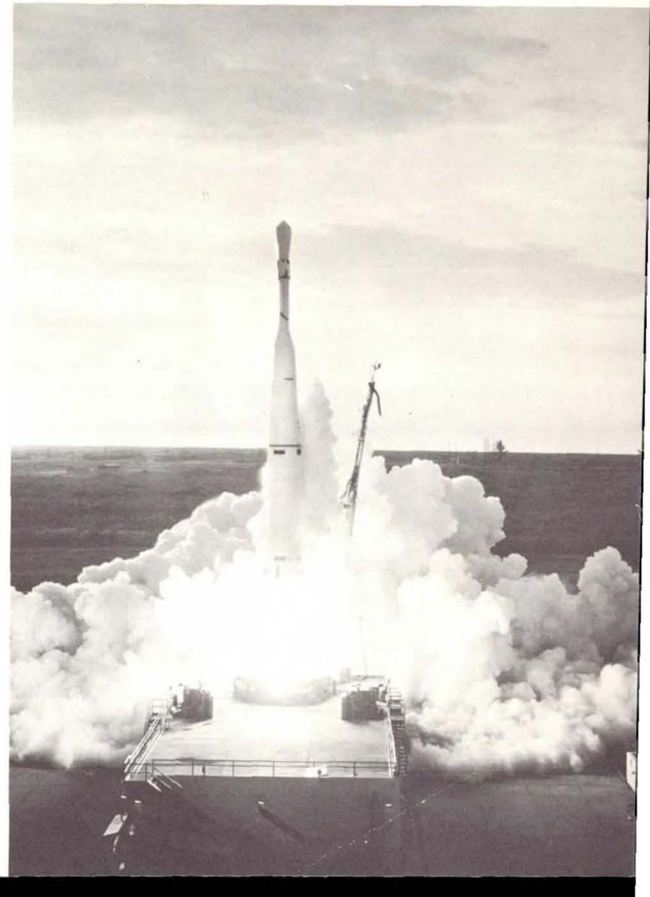


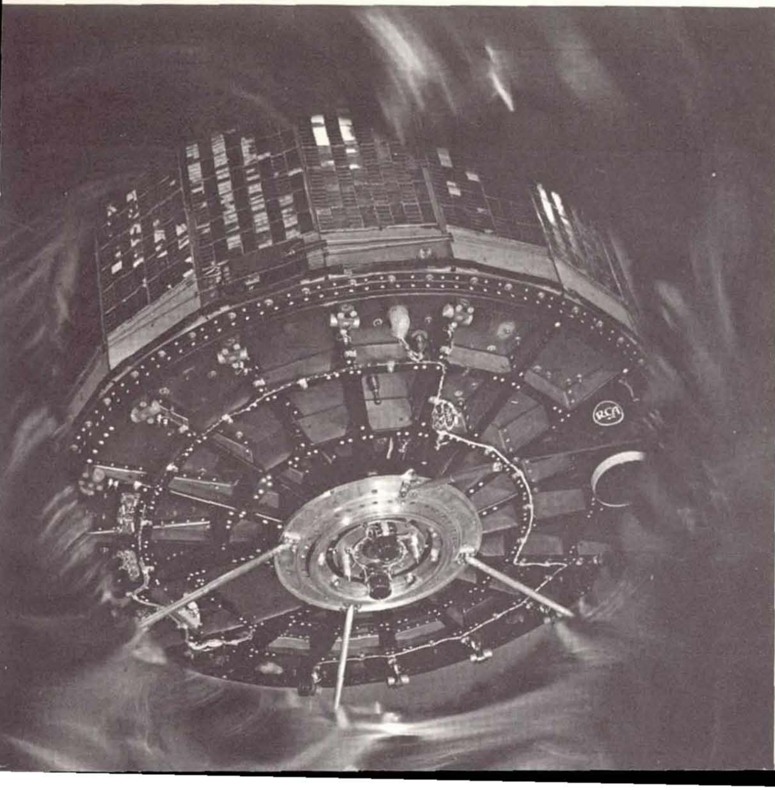
TIROS picture shows the Great Lakes of the United States and Canada.



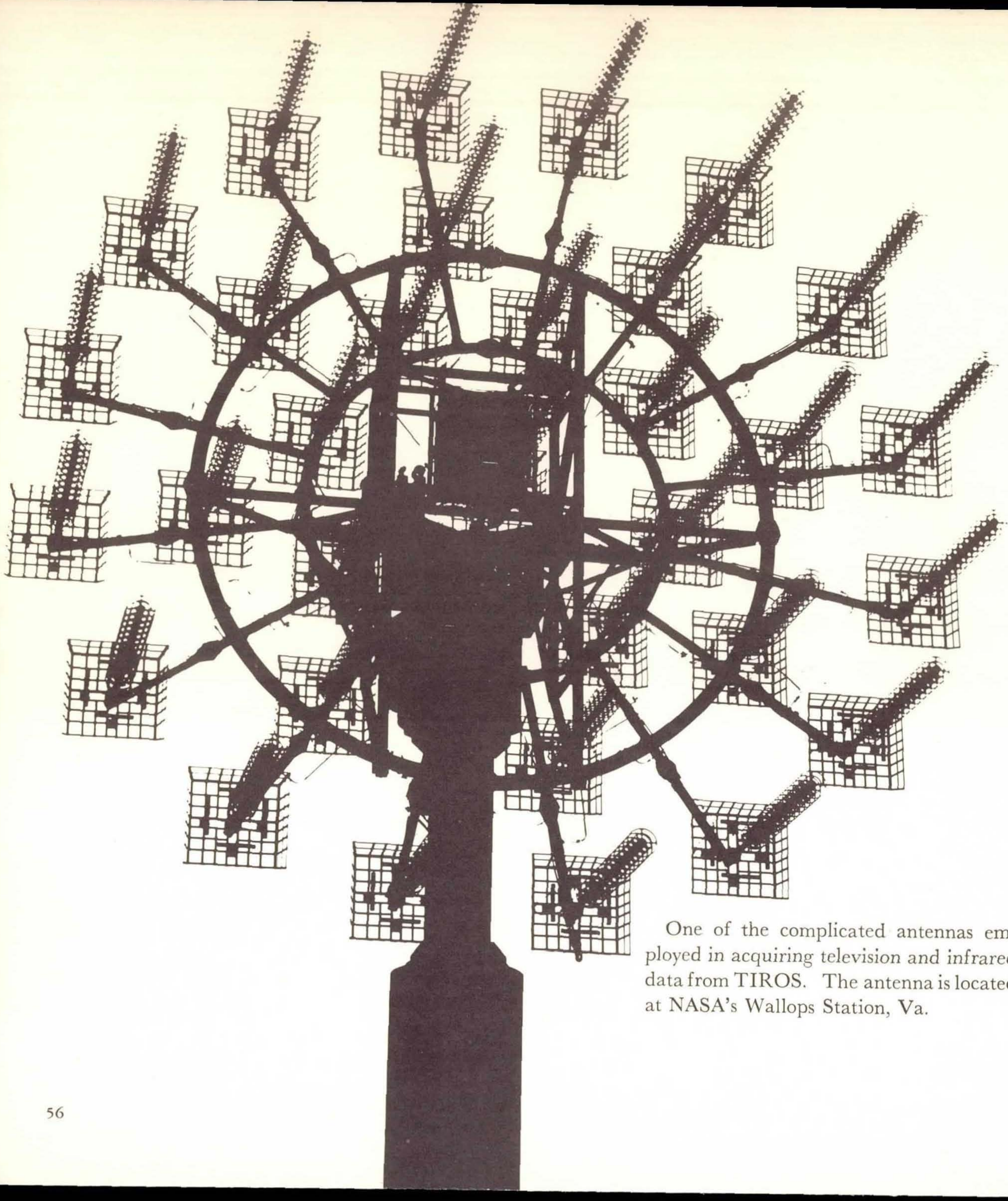
Many tests precede the orbiting of TIROS satellites. This machine checks functioning of TIROS stabilization system under simulated orbital conditions.

Thor-Able launches TIROS I, April 1, 1960. Other TIROS launches (all by Delta): TIROS II, November 23, 1960; TIROS III, July 12, 1961; TIROS IV, February 8, 1963; TIROS V, June 19, 1962; TIROS VI, September 18, 1962; TIROS VII, June 19, 1963; and TIROS VIII, December 21, 1963.

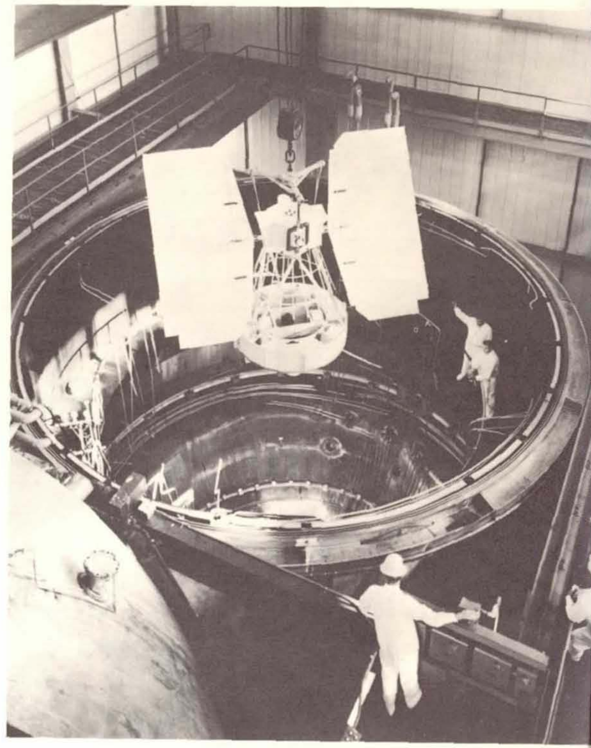




TIROS spin test. TIROS (an acronym for Television and Infra-Red Observation Satellite) sends data on reflected solar radiation and emitted terrestrial heat radiation in addition to cloud pictures.



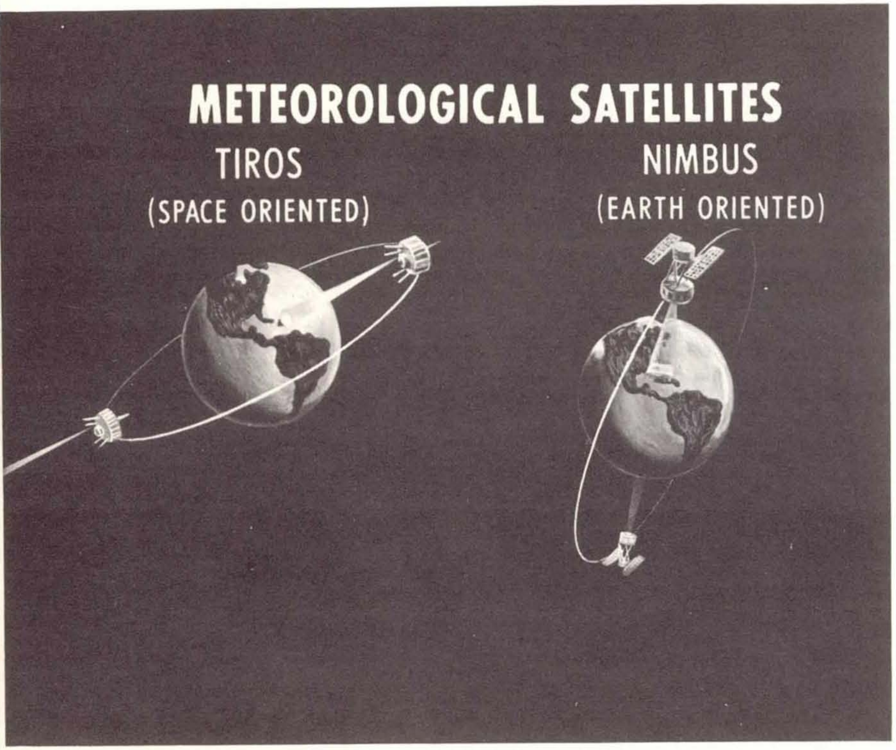
One of the complicated antennas employed in acquiring television and infrared data from TIROS. The antenna is located at NASA's Wallops Station, Va.

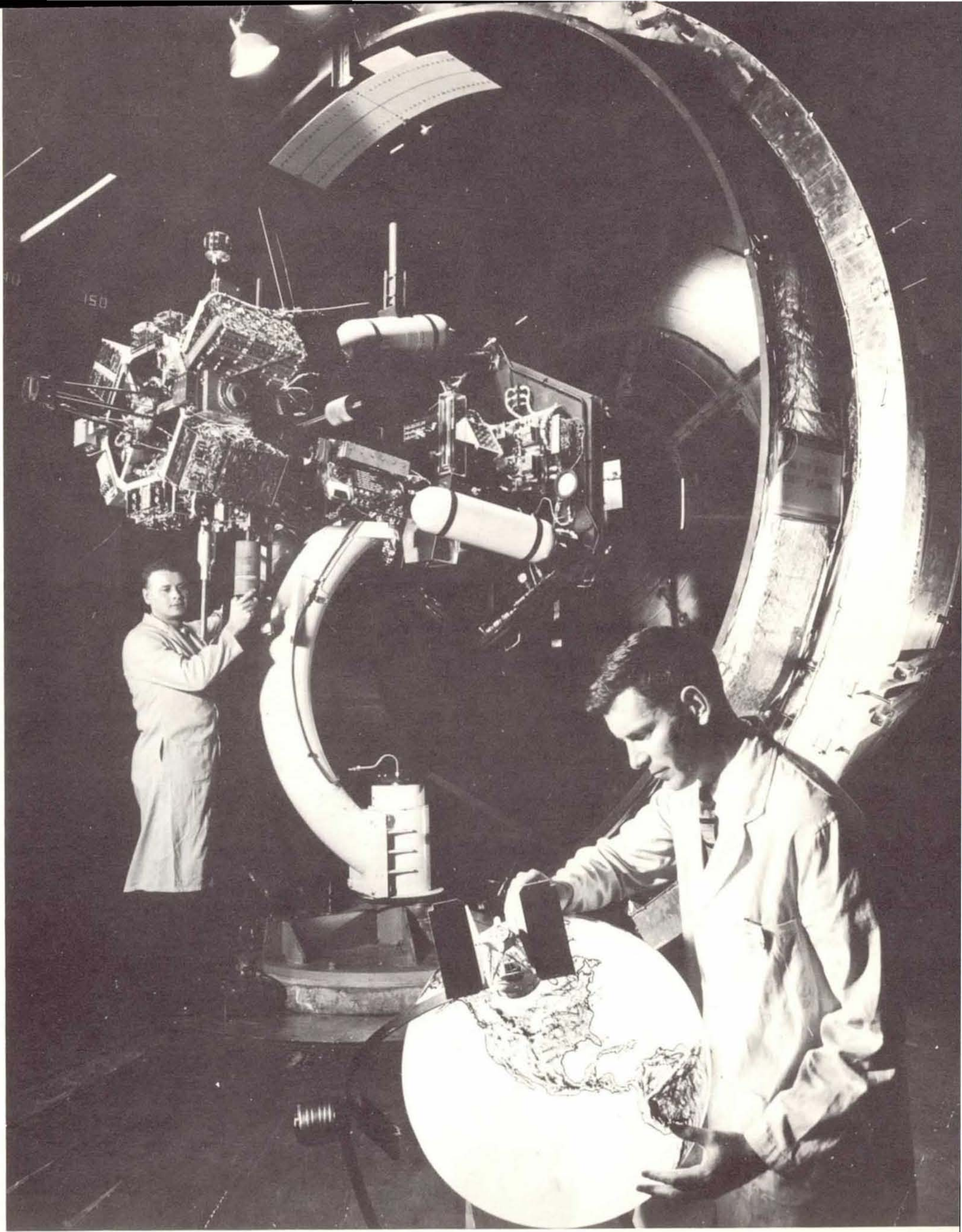


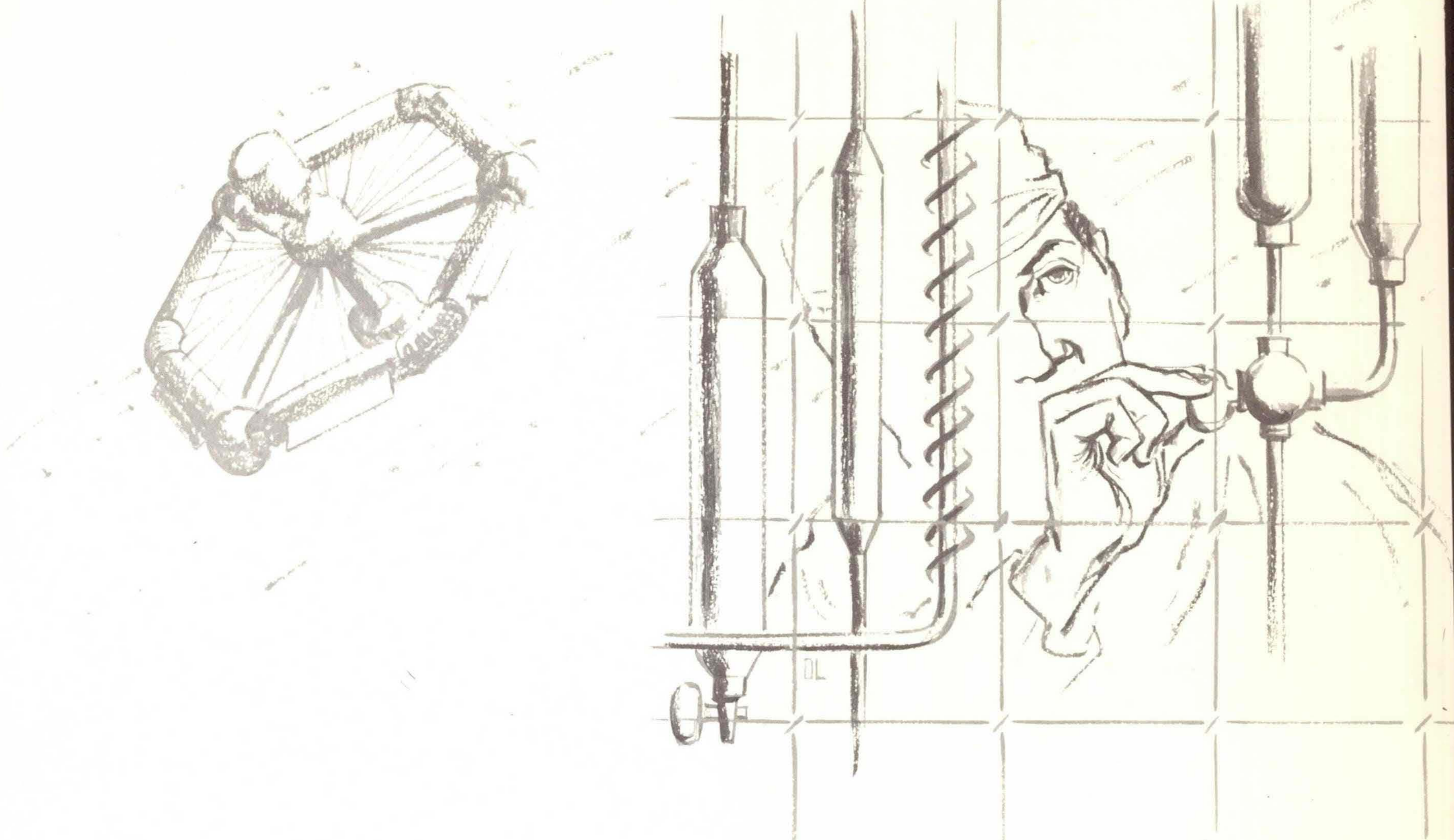
Experiments with TIROS have aided in development of Nimbus, an advanced weather satellite. Nimbus model is lowered in space environmental chamber for testing.

Stabilization and control tests are run on a prototype Nimbus subsystem (*right*) to check the horizon sensor and other equipment that will keep the Nimbus cameras locked on earth.

Among the improvements that Nimbus will have over TIROS are cameras that always point to earth (instead of cameras that alternately face toward and away from earth) and a polar (north-south) orbit that will enable it to observe the entire globe.



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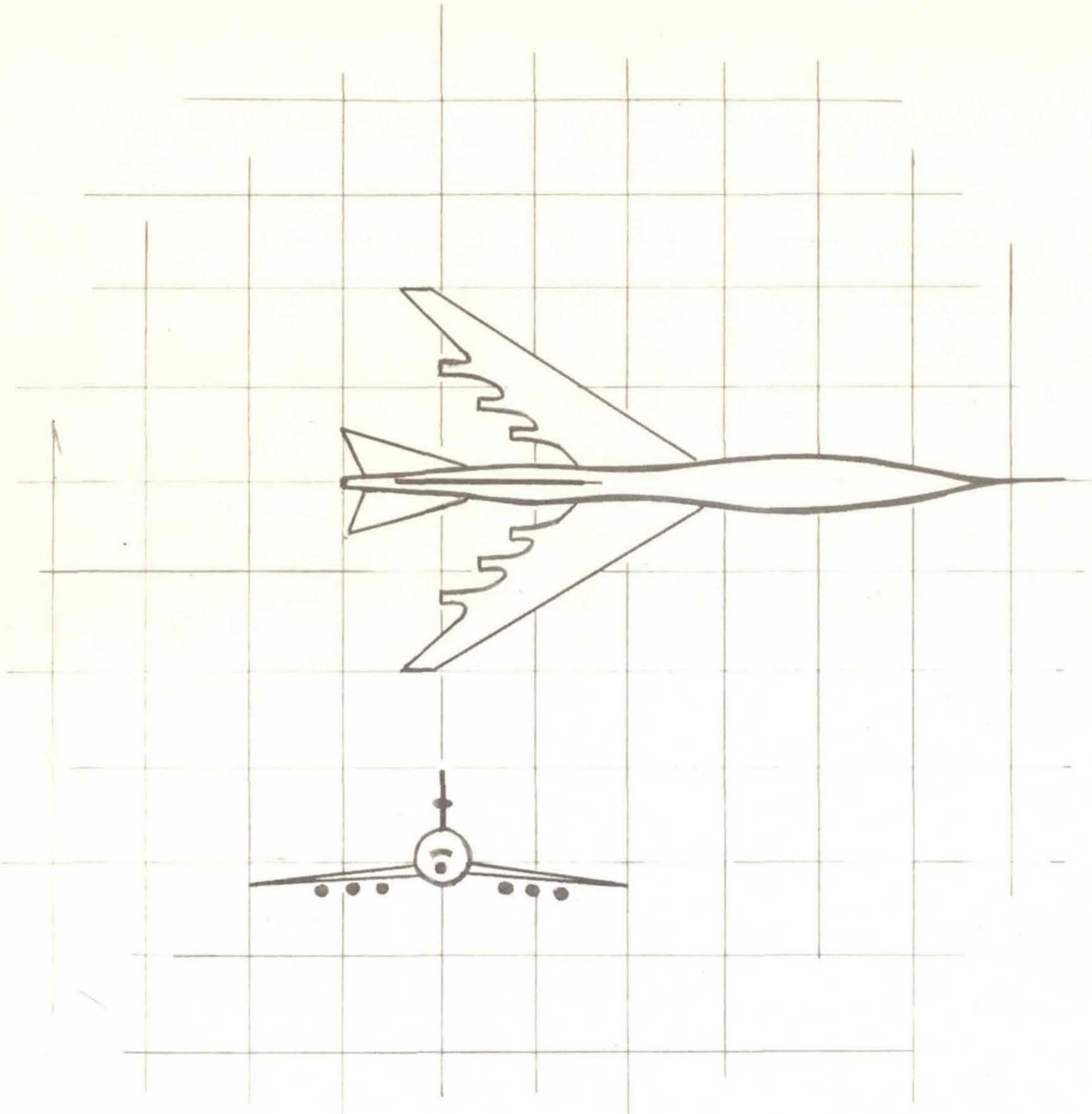
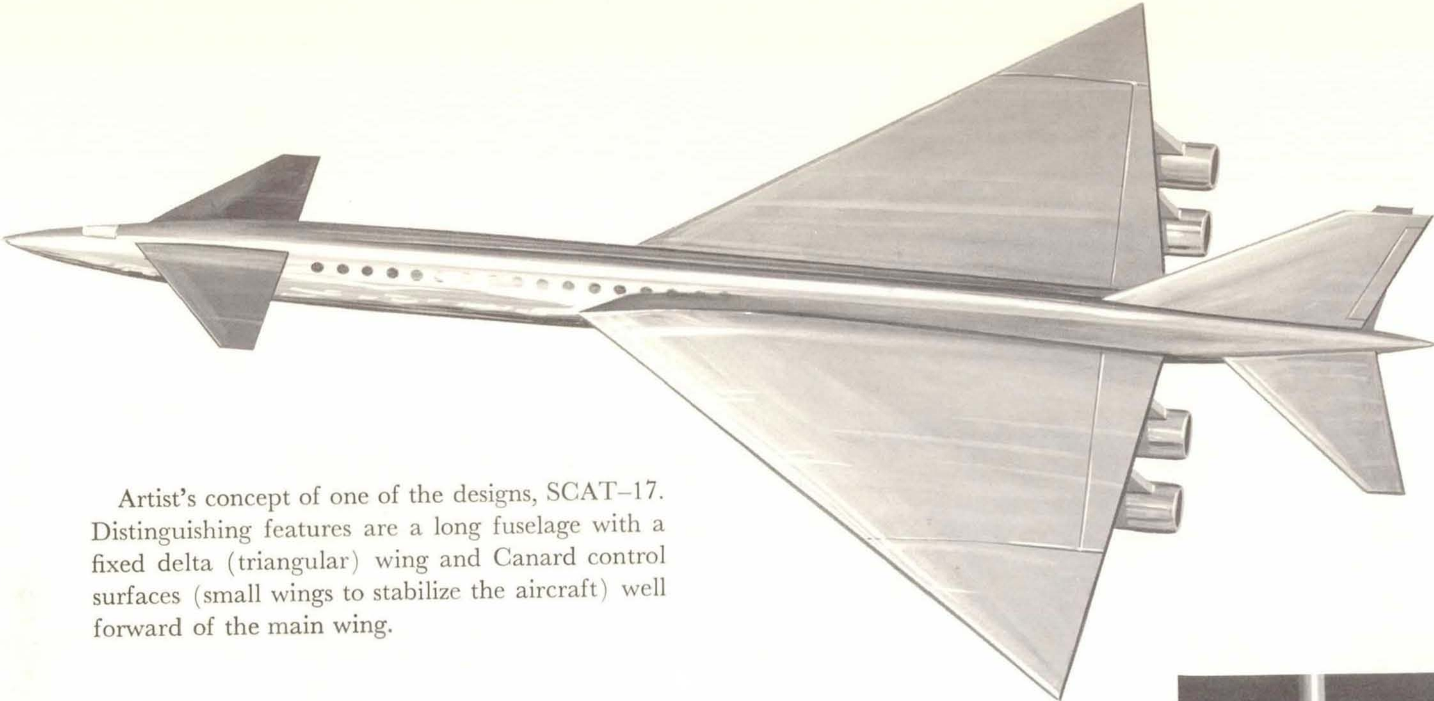


ADVANCED RESEARCH LOOKS TO THE FUTURE

Basic research, which is fundamental not only to progress in space but also to mankind's advances, is being conducted to solve the myriad problems involved in space exploration and aircraft development. NASA's advanced research programs touch upon all areas of science and technology and encompass current and possible future NASA programs. Following are illustrations showing aspects of some representative investigations.

NASA is engaged in intensive research to provide United States industry with information basic to construction of a safe and economically practicable supersonic commercial air transport (SCAT). Here an engineer checks three promising models between wind tunnel tests.

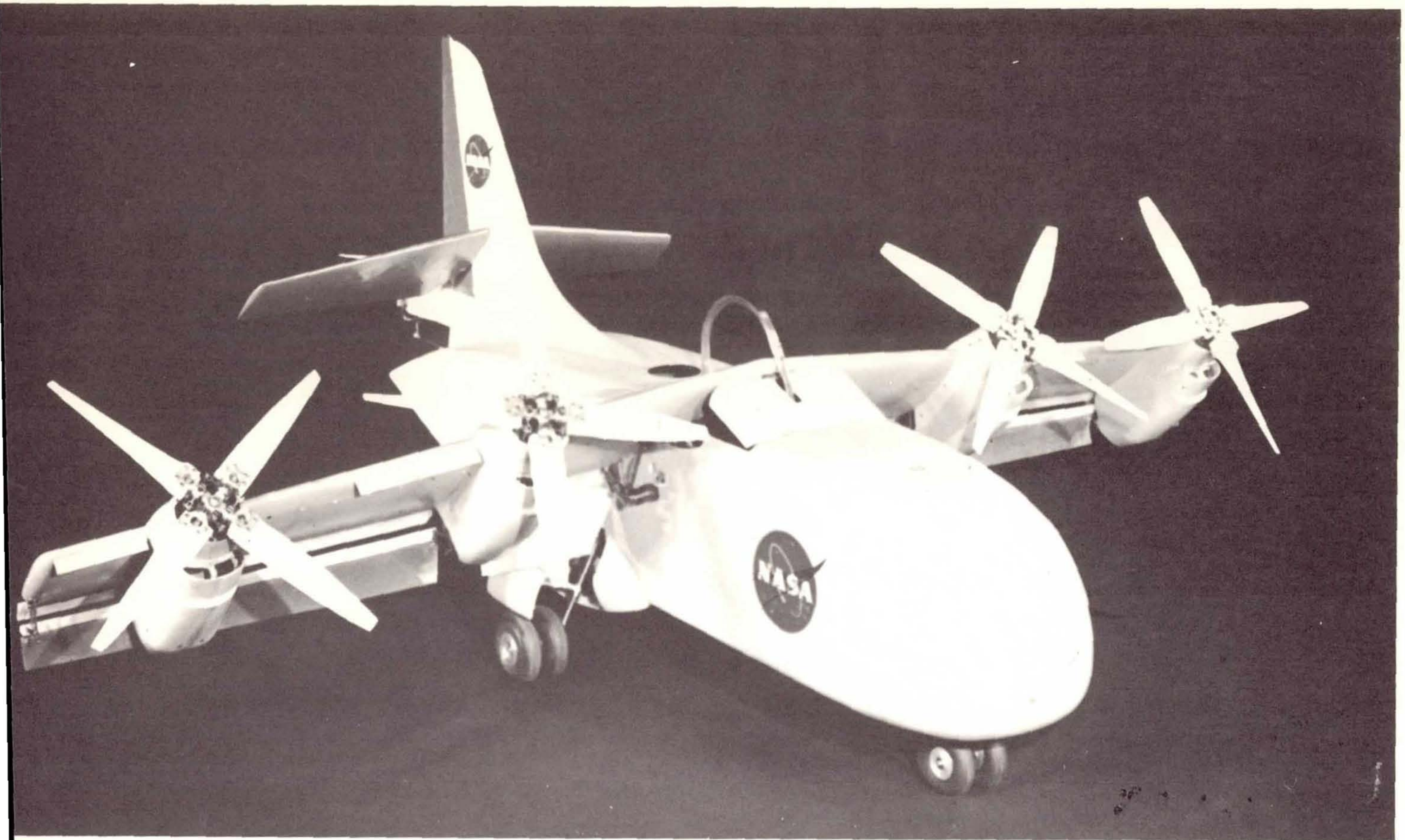


Artist's concept of one of the designs, SCAT–17. Distinguishing features are a long fuselage with a fixed delta (triangular) wing and Canard control surfaces (small wings to stabilize the aircraft) well forward of the main wing.

Another promising design, SCAT–16, features a variable-sweep wing. Here the extended wing provides extra lift for take-off and landing.

SCAT–16 with wings swept back for efficient supersonic flight.

NASA is also testing various designs of Vertical and Short Take-off and Landings (V/STOL) craft for civilian and military uses. One is the tilt-wing: wing vertical for take-off and landing, horizontal for flying.



Another experimental model is the ducted fan V/STOL.

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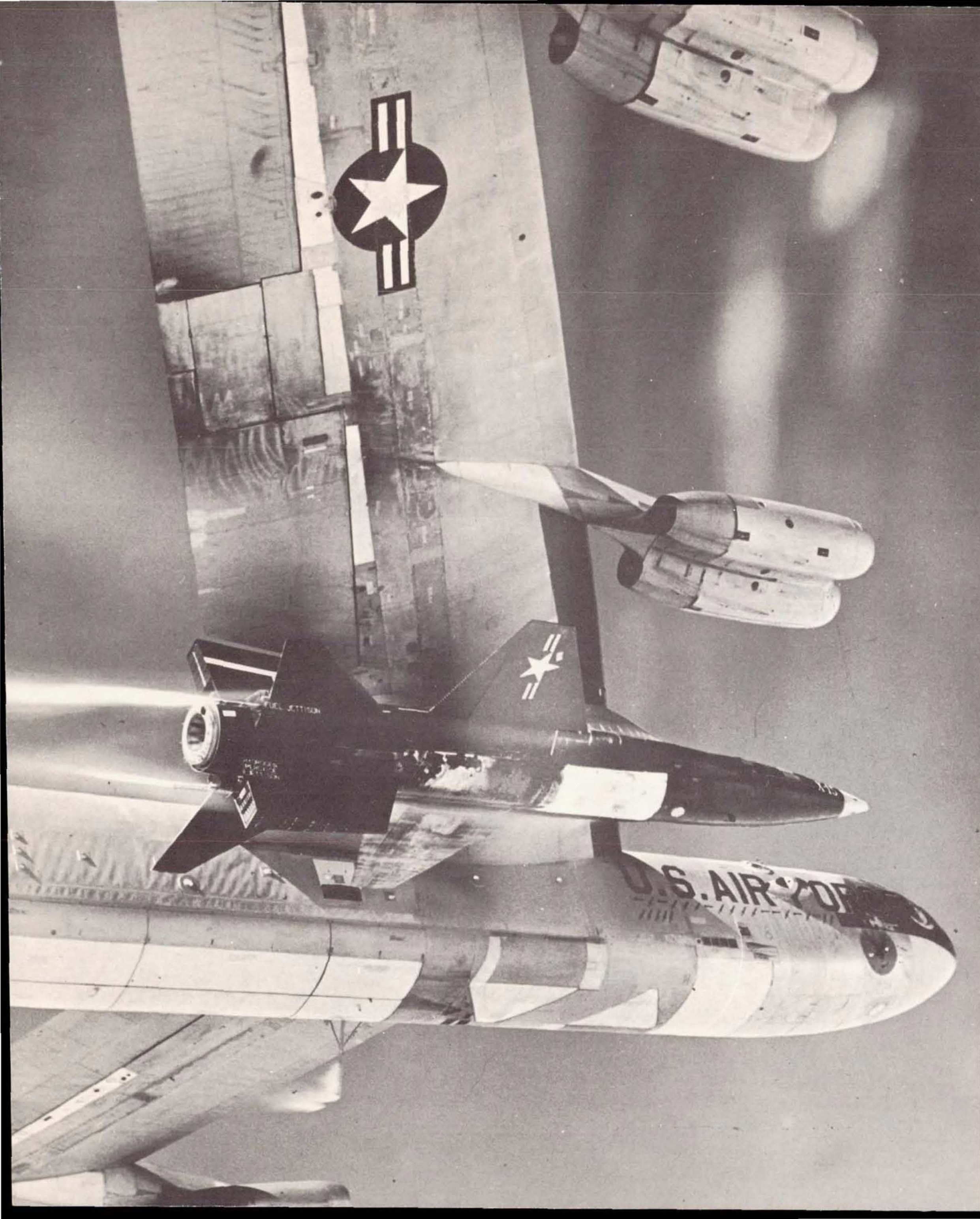
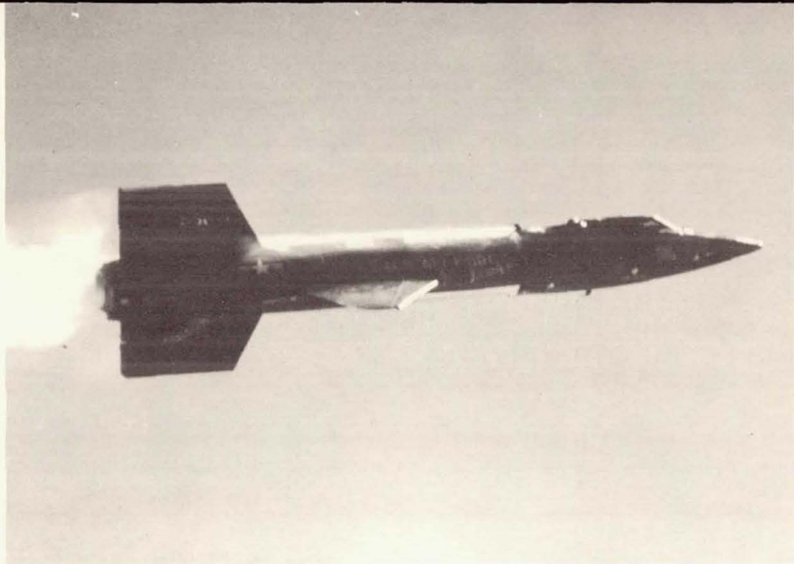
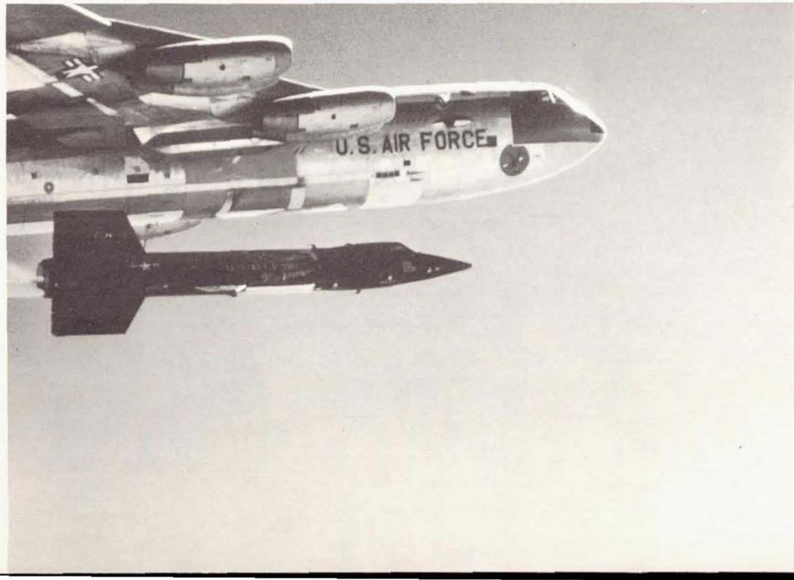


The X–15 research airplane, the fastest and highest flying aircraft in the world, is held to the wing of a B–52 aircraft until separation for test flight starting at a 45,000-foot altitude.

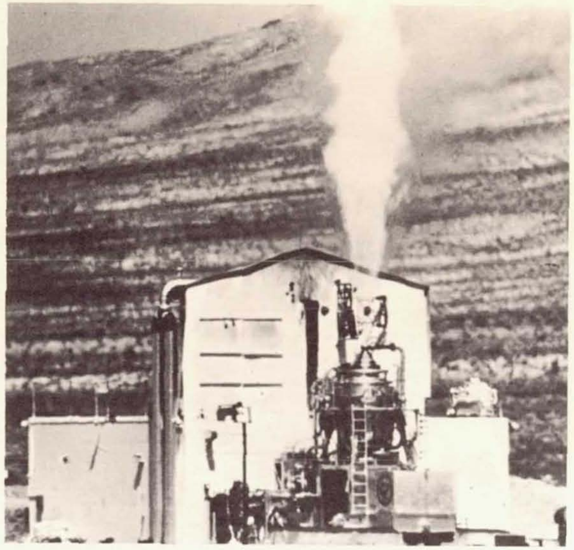


The 57,000-pound thrust rocket engine of the X–15 ignites. The aircraft has been flown at more than 4,000 miles per hour and has reached altitudes of more than 66 miles.

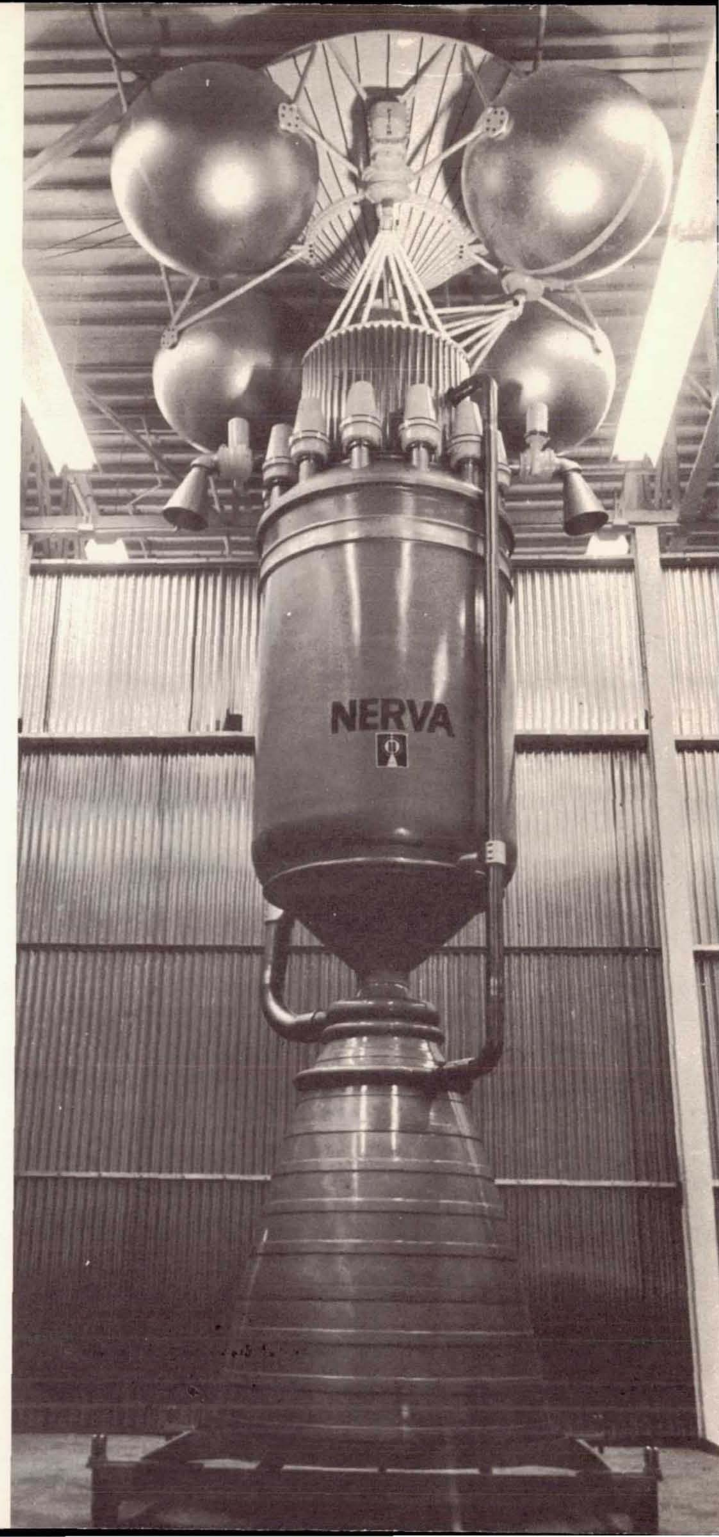
The X–15 at the moment of separation from the B–52. A joint Air Force, NASA, and Navy project, the X–15 is a NASA-conceived research airplane that is providing valuable information for both aeronautical and space technologies.



Mission completed, the X–15 streaks in for a landing.



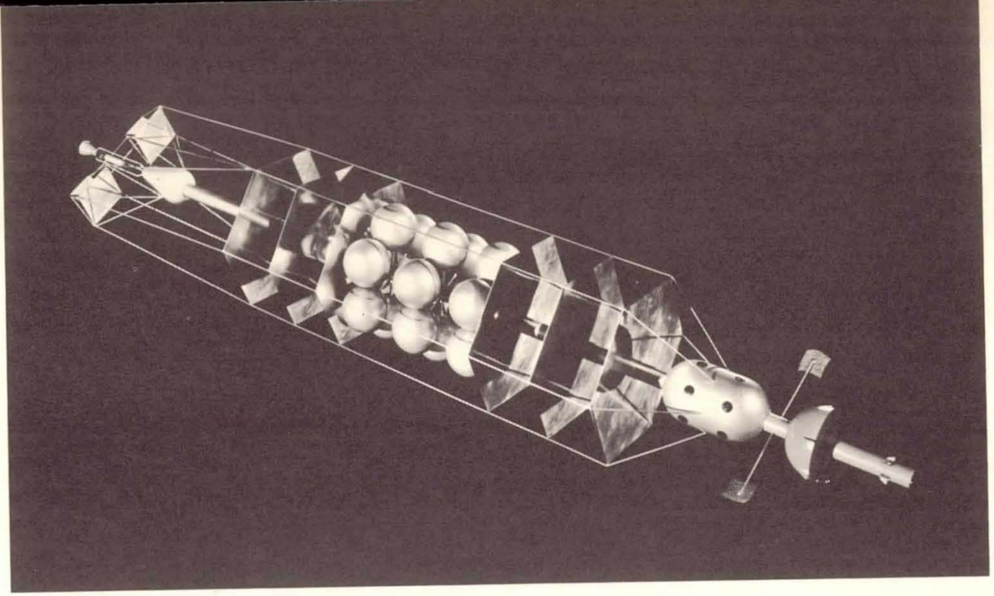
Kiwi reactor under test. Goal of Kiwi, named for the flightless Australian bird, is to provide basic reactor design information for a nuclear rocket.



PARASEV (Paraglider Research Vehicle). Adaptations of the paraglider, based on a concept developed by Francis M. Rogallo of NASA's Langley Research Center, are being developed for such possible uses as recovery of spacecraft and boosters.

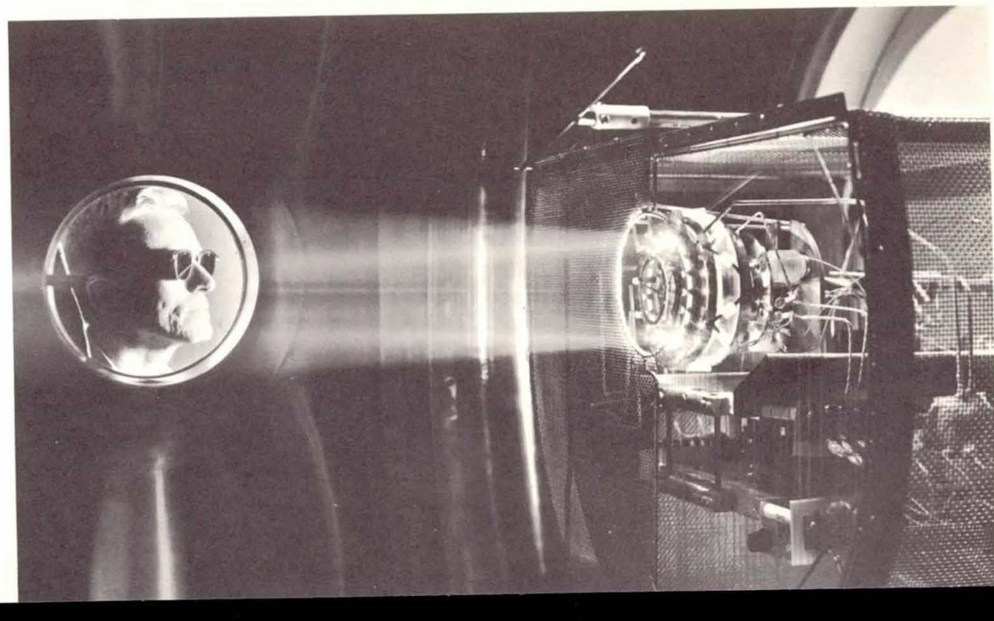
Mock-up of NERVA (Nuclear Engine for Rocket Vehicle Application). Power from a nuclear reactor is expected to be utilized for extended exploration of the solar system.

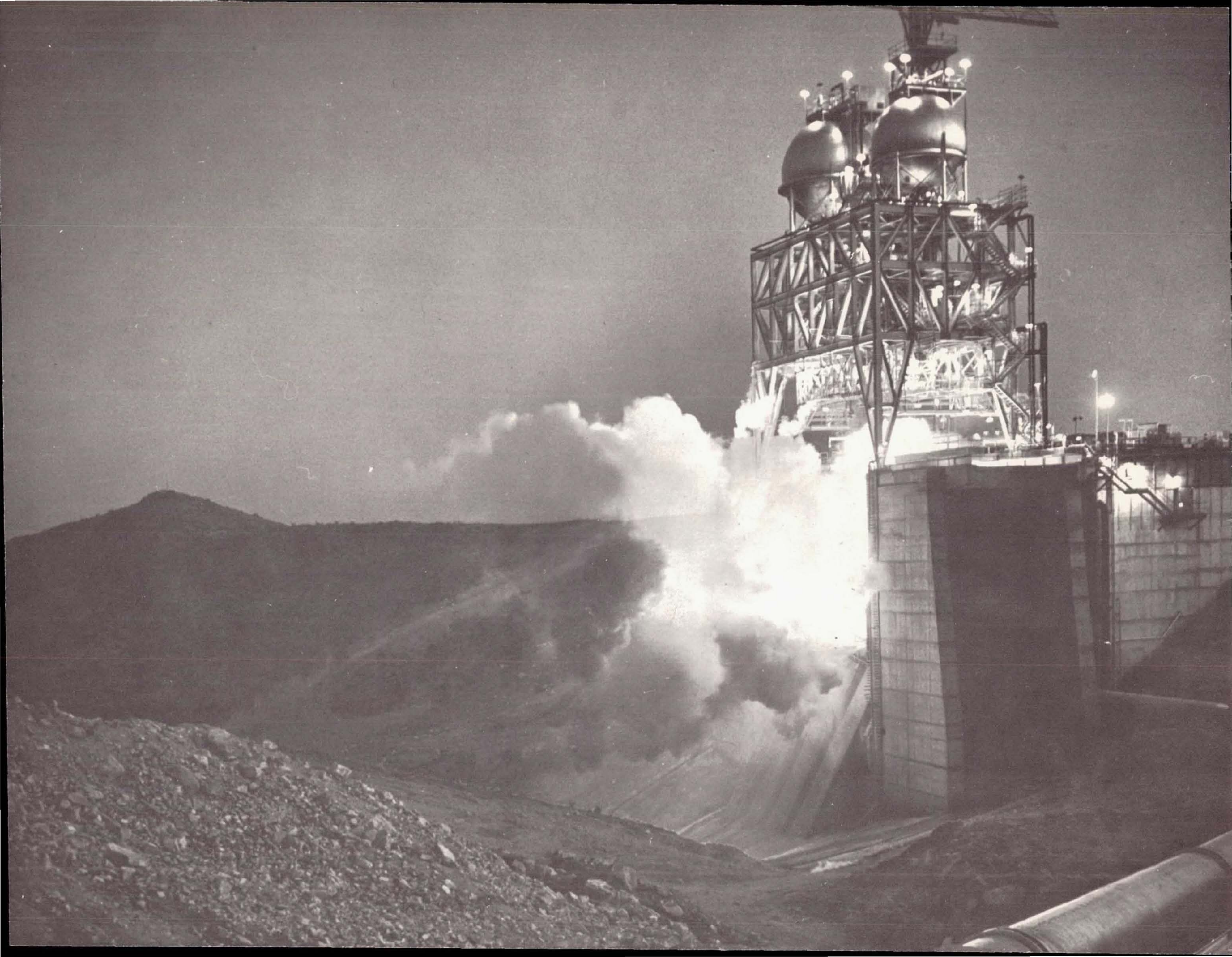
Prototype ion rocket. The ion rocket would electrically accelerate charged atomic particles to produce thrust. Although providing only a few pounds of thrust, an ion rocket could operate for long periods on very little fuel.



Model of hypothetical manned interplanetary spacecraft powered by nuclear energy. The nuclear rocket program is being carried out by NASA with the Atomic Energy Commission having responsibility for the reactor development.

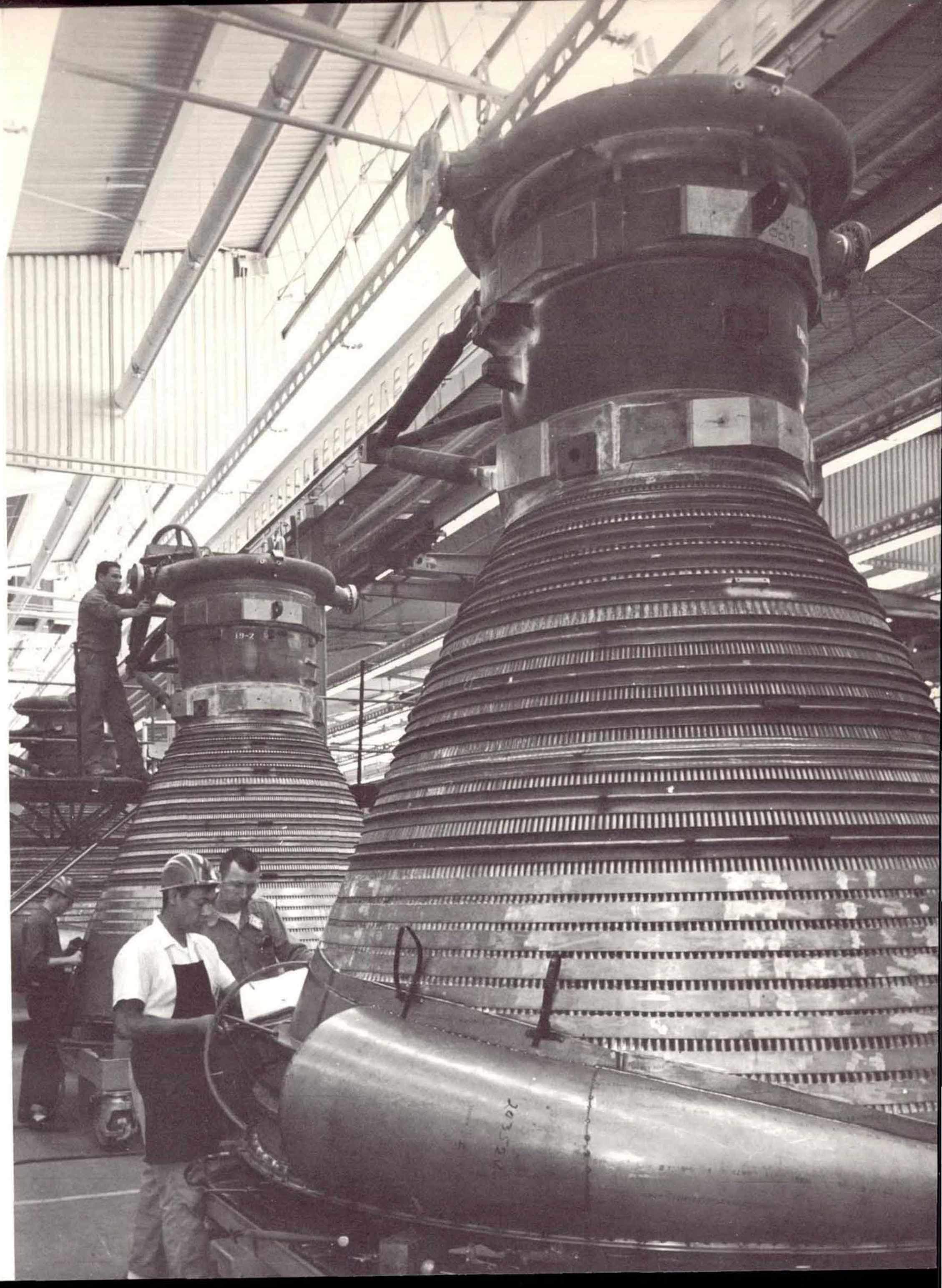
A technician observes the glow of ionized atoms as they rush from an operating ion rocket in laboratory. In space, where gravity is negligible, an ion rocket could accelerate a spacecraft to tremendous velocities.





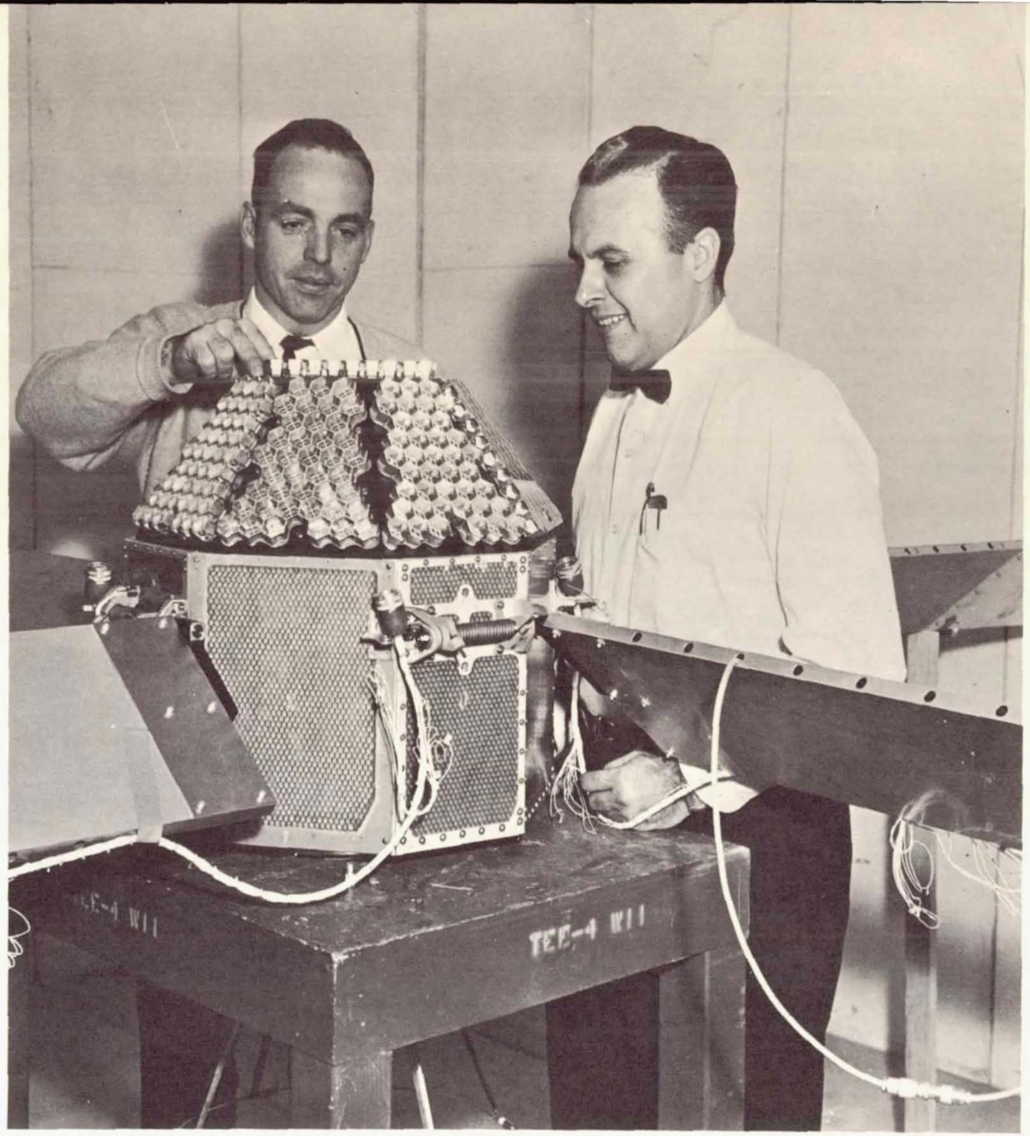
The F–1 engine, 1.5 million-pound thrust, is ground tested (*left*). Intended for use in Saturn V, each F–1 generates as much thrust as all eight of the engines clustered in the Saturn I first stage.

Manufacturing line for the F–1 (*right*). Five F–1 engines will be clustered in the first stage of Saturn V, which will launch the three-man Apollo spacecraft to the moon.

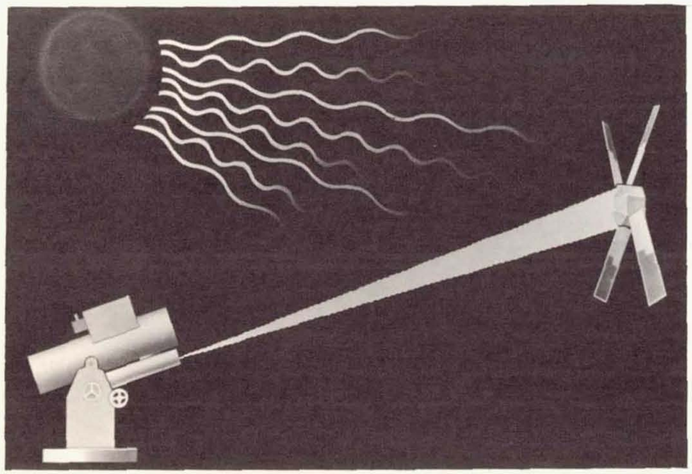


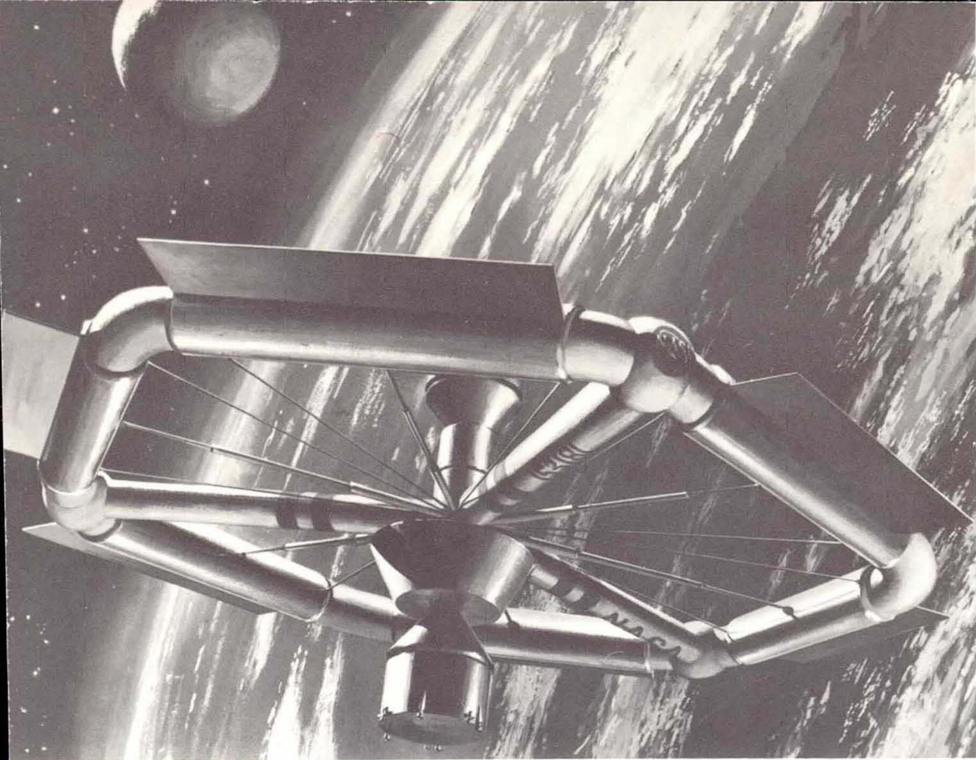
Model of SNAP–8 (System for Nuclear Auxiliary Power) under development by NASA and AEC to provide a long-lasting electric power source for spacecraft instruments.

NASA's experiments with the laser include its possible use in tracking spacecraft. Here a satellite is fitted with highly-polished quartz prisms to reflect laser light. LASER is an acronym for Light Amplification by Stimulated Emission of Radiation.

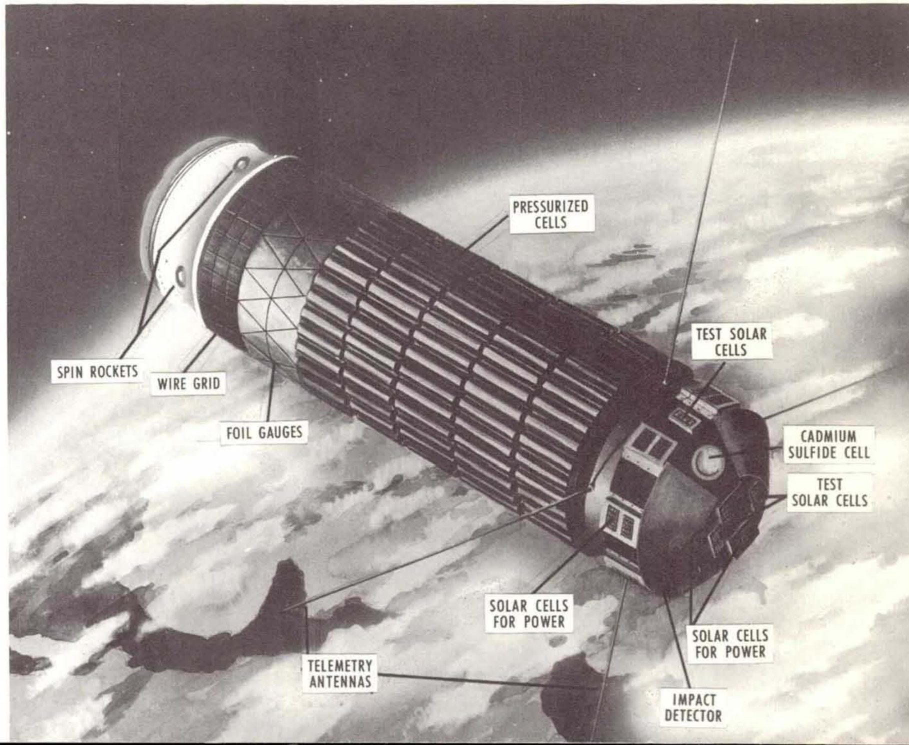


Artist's sketch of laser tracking. The time the beam takes for the round trip and the angle of the beam enable scientists to calculate the satellite's location.





Artist's concept of a manned orbital laboratory, one of several possible future projects on which NASA studies are in progress.



Explorer XVI, launched December 16, 1962, provided data on dangers that meteroids pose to manned space flight. This is one of many advanced research studies of the space environment and space operations that support flight programs.

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